THE CASE AGAINST EVOLUTION

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TO MY MOTHER

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Nihil Obstat

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FOREWORD

The literature on the subject of evolution has already attained such vast dimensions that any attempt to add to it has the appearance of being both superfluous and presumptuous. It is, however, in the fact that the generality of modern works are frankly partisan in their treatment of this theme that the publication of the present work finds justification.

For the philosophers and scientists of the day evolution is evidently something which admits of no debate and which must be maintained at all costs. These thinkers are too intent upon making out a plausible case for the theory to take anything more than the mildest interest in the facts opposed to it. If they advert to them at all, it is always to minimize, and never to accentuate, their antagonistic force. For the moment, at any rate, the minds of scientific writers are closed to unfavorable, and open only to favorable, evidence, so that one must look elsewhere than in their pages for adequate presentation of the case against evolution.

The present work aims at setting forth the side of the question which it is now the fashion to suppress. It refuses to be bound by the convention which prescribes that evolution shall be leniently criticized. It proceeds, in fact, upon the opposite assumption, namely, that a genuinely scientific theory ought not to stand in need of indulgence, but should be able, on the contrary, to endure the acid test of merciless criticism.

Evolution has been termed a "necessary hypothesis." We have no quarrel with the phrase, provided it really means evolution as an hypothesis, and not evolution as a dogma. For, obviously, the problem of a gradual differentiation of

organic species cannot even be investigated upon the fixistic assumption, inasmuch as this assumption destroys the problem at the very outset. Unless we assume the possibility, at least, that modern species of plants and animals may have been the product of a gradual process, there is no problem to investigate. It is, however, a far cry from the possibility to the actuality; and the mere fact that an hypothesis is necessary as an incentive to investigation does not by any means imply that the result of the investigation will be the vindication of its inspirational hypothesis. On the contrary, research often results in the overthrow of the very hypothesis which led to its inception. We can, therefore, quite readily admit the necessity of evolution as an hypothesis, while rejecting its necessity as a dogma.

Assent to evolution as a dogma is advocated not only by materialists, who see in evolutionary cosmogony proof positive of their monism and the complete overthrow of the idea of Creation, but also by certain Catholic scientists, who seem to fear that religion may become involved in the anticipated ruin of fixism. Thus all resistance to the theory of evolution is deprecated by Father Wasmann and Canon Dorlodot on the assumption that the ultimate triumph of this theory is inevitable, and that failure to make provision for this eventuality will lead to just such another blunder as theologians of the sixteenth century made in connection with the Copernican theory. Recollection of the Galileo incident is, doubtless, salutary, in so far as it suggests the wisdom of caution and the imperative necessity of close contact with ascertained facts, but a consideration of this sort is no warrant whatever for an uncritical acceptance of what still remains unverified. History testifies that verification followed close upon the heels of the initial proposal of the heliocentric theory, but the whole trend of scientific discovery has been to destroy, rather than to confirm, all definite formulations of the evolutional theory, in spite of the immense erudition expended in revising them.

There is, in brief, no parity at all between Transformism and the Copernican theory. Among other points of difference, Tuccimei notes especially the following: "The Copernican system," he remarks, "explains *that which is,* whereas evolution attempts to explain *that which was;* it enters, in other words, into the problem of origins, an insoluble problem in the estimation of many illustrious evolutionists, according to whom no experimental verification is possible, given the processes and factors in conjunction with which the theory was proposed. But what is of still greater significance for those who desire to see a parallelism between the two theories is the fact that the Copernican system became, with the discoveries of Newton, a demonstrated thesis, scarcely fifty years after the death of Galileo; the theory of evolution, on the other hand, is at the present day no longer able to hold its own even as an hypothesis, so numerous are its incoherencies and the objections to it raised by its own partisans." ("La Decadenza di una Teoria," 1908, p. 11.)

The prospect, then, of a renewal of the Galileo episode is exceedingly remote. Far more imminent to the writer seems the danger that the well-intentioned rescuers of religion may be obliged to perform a most humiliating *volte face,* after having accepted all too hastily a doctrine favored only for the time being in scientific circles. It is, in fact, by no means inconceivable that the scientific world will eventually discard the now prevalent dogma of evolution. In that case those who have seen fit to reconcile religion with evolution will have the questionable pleasure of unreconciling it in response to this reversal of scientific opinion.

On the whole, the safest attitude toward evolution is the agnostic one. It commits us to no uncertain position. It does not compromise our intellectual sincerity by requiring us to accept the dogmatism of scientific orthodoxy as a substitute for objective evidence. It precludes the possible embarrassment of having to unsay what we formerly said. And last, but not least, it is the attitude of simple truth; for the truest

thing that Science is, or ever will be, able to say concerning the problem of organic origins is that she knows nothing about it.

In the present work, we shall endeavor to show that Evolution has long since degenerated into a dogma, which is believed in spite of the facts, and not on account of them. The first three chapters deal with the theory in general, discussing in turn its genetical, morphological, and geological aspects. The last three chapters are devoted to the problem of origins, and treat of the genesis of life, of the human soul, and of the human body, respectively.

While this book is in no sense a work of "popular science," I have sought to broaden its scope and interest by combining the scientific with the philosophic viewpoint. Certain portions of the text are unavoidably technical, but there is much, besides, that the general reader will be able to follow without difficulty. Students, especially of biology, geology, and experimental psychology, may use it to advantage as supplementary reading in connection with their textbooks.

I wish to acknowledge herewith my indebtedness to the Editor of the *Catholic Educational Review,* Rev. George Johnson, Ph.D., to whose suggestion and encouragement the inception of this work was largely due. I desire also to express my sincere appreciation of the services rendered in the revision of the manuscript by the Rev. Edward Wenstrup, O.S.B., Professor of Zoölogy, St. Vincent College, Pennsylvania.

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St. Vincent Archabbey,
January 30, 1925.

PART I

EVOLUTION IN GENERAL

I

EVOLUTION IN GENERAL

CHAPTER I

THE PRESENT CRISIS IN EVOLUTIONARY THOUGHT

Three prominent men, a scientist, a publicist, and an orator, have recently made pronouncements on the theory of Evolution. The trio, of course, to whom allusion is made, are Bateson, Wells, and Bryan. As a result of their utterances, there has been a general reawakening of interest in the problem to which they drew attention. Again and again, in popular as well as scientific publications, men are raising and answering the question: "Is Darwinism dead?" Manifold and various are the answers given, but none of them appears to take the form of an unqualified affirmation or negation. Some reply by drawing a distinction between Darwinism, as a synonym for the theory of evolution in general, and Darwinism, in the sense of the particular form of that theory which had Darwin for its author. Modern research, they assure us, has not affected the former, but has necessitated a revision of ideas with respect to the latter. There are other forms of evolution besides Darwinism, and, as a matter of fact, not Darwin, but Lamarck was the originator of the scientific theory of evolution. Others, though imitating the prudence of the first group in their avoidance of a categorical answer, prefer to reply by means of a distinction based upon their interpretation of the realities of the problem rather than upon any mere terminological consideration.

Of the second group, some, like Osborn, distinguish between the *law* of evolution and the theoretical *explanations* of this law proposed by individual scientists. The existence of the law itself, they insist, is not open to question; it is only with respect to hypotheses explanatory of the aforesaid law that doubt and disagreement exist. The obvious objection to such a solution is that, if evolution is really a law of nature, it ought to be reducible to some clear-cut mathematical formula comparable to the formulations of the laws of constant, multiple, and reciprocal proportion in chemistry, or of the laws of segregation, assortment, and linkage in genetics. Assuming, then, that it is a genuine law, how is it that to-day no one ventures to formulate this evolutional law in definite and quantitative terms?

Others, comprising, perhaps, a majority, prefer to distinguish between the *fact* and the *causes* of evolution. Practically all scientists, they aver, agree in accepting evolution as an established fact; it is only with reference to the agencies of evolution that controversy and uncertainty are permissible. To this contention one may justly reply that, by all the canons of linguistic usage, a fact is an observed or experienced event, and that hitherto no one in the past or present has ever been privileged to witness with his senses even so elemental a phenomenon in the evolutionary process as the actual origin of a new and genuine organic species. If, however, the admission be made that the term "fact" is here used in an untechnical sense to denote an inferred event postulated for the purpose of interpreting certain natural phenomena, then the statement that the majority of modern scientists agree as to the "fact" of evolution may be allowed to stand, with no further comment than to note that the formidable number and prestige of the advocates fail to intimidate us. Considerations of this sort are wholly irrelevant, for in science no less than in philosophy authority is worth as much as its arguments and no more.

The limited knowledge of the facts possessed by the biolo-

gists of the nineteenth century left their imaginations perilously unfettered and permitted them to indulge in a veritable orgy of theorizing. Now, however, that the trail blazed by the great Augustinian Abbot, Mendel, has been rediscovered, work of real value is being done with the seed pan, the incubator, the microtome, etc., and the wings of irresponsible speculation are clipped. Recent advances in this new field of Mendelian genetics have made it possible to subject to critical examination all that formerly went under the name of "experimental evidence" of evolution. Even with respect to the inferential or circumstantial evidence from palæontology, the enormous deluge of fossils unearthed by the tireless zeal of modern investigators has annihilated, by its sheer complexity, the hasty generalizations and facile simplifications of a generation ago, forcing the adoption of a more critical attitude. Formerly, a graded series of fossil genera sufficed for the construction of a "palæontological pedigree"; now, the worker in this field demands that the chain of descent shall be constructed with species, instead of genera, for links—"Not till we have linked species into lineages, can we group them into genera." (F. A. Bather, *Science*, Sept. 17, 1920, p. 264.) This remarkable progress in scientific studies has tended to precipitate the crisis in evolutionary thought, which we propose to consider in the present chapter. Before doing so, however, it will be of advantage to formulate a clear statement of the problem at issue.

Evolution, or transformism, as it is more properly called, may be defined as the theory which regards the present species of plants and animals as modified descendants of earlier forms of life. Nowadays, therefore, the principal use of the term evolution is to denote the developmental theory of organic species. It is, however, a word of many senses. In the eighteenth century, for example, it was employed in a sense at variance with the present usage, that is, to designate the non-developmental theory of embryological encasement or preformation as opposed to the developmental theory of epi-

genesis. According to the theory of encasement, the adult organism did not arise by the generation of new parts (epigenesis), but by a mere "unfolding" (*evolutio*) of preëxistent parts. At present, however, evolution is used as a synonym for transformism, though it has other meanings, besides, being sometimes used to signify the formation of inorganic nature as well as the transformation of organic species.

Evolution, in the sense of transformism, is opposed to fixism, the older theory of Linné, according to whom no *specific* change is possible in plants and animals, all organisms being assumed to have persisted in essential sameness of type from the dawn of organic life down to the present day. The latter theory admits the possibility of environmentally-induced modifications, which are non-germinal and therefore non-inheritable. It also admits the possibility of germinal changes of the varietal, as opposed to the specific, order, but it maintains that all such changes are confined within the limits of the species, and that the boundaries of an organic species are impassable. Transformism, on the contrary, affirms the possibility of specific change, and assumes that the boundaries of organic species have actually been traversed.

What, then, is an organic species? It may be defined as a group of organisms endowed with the *hardihood* necessary to survive and propagate themselves under natural conditions (*i.e.* in the wild state), exhibiting a common inheritable type, differing from one another by no major germinal difference, perfectly interfertile with one another, but *sexually incompatible* with members of an alien specific group, in such wise that they produce hybrids wholly, or partially, sterile, when crossed with organisms outside their own specific group.

David Starr Jordan has wisely called attention to the requisite of viability and survival under natural conditions. "A species," he says, "is not merely a form or group of individuals distinguished from other groups by definable features. A complete definition involves longevity. A species is a kind of animal or plant which has run the gantlet of the ages and

persisted. . . . A form is not a species until it has 'stood.'" (*Science,* Oct. 20, 1922, p. 448.)

Sexual (gametic) incompatibility as a criterion of specific distinction, presupposes the bisexual or biparental mode of reproduction, namely, syngamy, and is therefore chiefly applicable to the metista, although, if the view tentatively proposed by the protozoölogist, E. A. Minchin, be correct, it would also be applicable to the protista. According to this view, no protist type is a true species, unless it is maintained by syngamy (*i.e.* bisexual reproduction)—"Not until syngamy was acquired," says Minchin, "could true species exist among the Protista." ("An Introduction to the Study of the Protozoa," p. 141.)

To return, however, to the metista, the horse (*Equus caballus*) and the ass (*Equus asinus*) represent two distinct species under a common genus. This is indicated by the fact that the mule, which is the hybrid offspring of their cross, is entirely sterile, producing no offspring whatever, when mated with ass, horse, or mule. Such total sterility, however, is not essential to the proof of specific differentiation; it suffices that the hybrid be less fertile than its parents. As early as 1686, sterility (total or partial) of the hybrid was laid down by John Ray as the fundamental criterion of specific distinction. Hence Bateson complains that Darwinian philosophy flagrantly "ignored the chief attribute of species first pointed out by John Ray that the product of their crosses is frequently sterile in a greater or lesser degree." (*Science,* Jan. 20, 1922, p. 58.)

Accordingly, the sameness of type required in members of the same species refers rather to the genotype, that is, the sum-total of internal hereditary factors latent in the germ, than to the phenotype, that is, the expressed somatic characters, viz. the color, structure, size, weight, and all other perceptible properties, in terms of which a given plant or animal is described. Thus it sometimes happens that two dis-

tinct species, like the pear-tree and the apple-tree, resemble each other more closely, as regards their external or somatic characters, than two varieties belonging to one and the same species. Nevertheless, the pear-tree and the apple-tree are so unlike in their germinal (genetic) composition that they cannot even be crossed.

According to all theories of transformism, new species arise through the transformation of old species, and hence evolutionists are at one in affirming the occurrence of specific change. When it comes, however, to assigning the agencies or factors, which are supposed to have brought about this transmutation of organic species, there is a wide divergence of opinion. The older systems of transformism, namely, Lamarckism and Darwinism, ascribed the modification of organic species to the operation of the external factors of the environment, while the later school of orthogenesis attributed it to the exclusive operation of factors residing within the organism itself.

Lamarckism, for example, made the formation of organs a response to external conditions imposed by the environment. The elephant, according to this view, being maladjusted to its environment by reason of its clumsy bulk, developed a trunk by using its nose to compensate for its lack of pliancy and agility. Here the use or function precedes the organ and molds the latter to its need. Darwinism agrees with Lamarckism in making the environment the chief arbiter of modification. Its explanation of the elephant's trunk, however, is negative rather than positive. This animal, it tells us, developed a trunk, because failure to vary in that useful direction would have been penalized by extermination.

Wilson presents, in a very graphic manner, the appalling problem which confronts evolutionists who seek to explain the adaptations of organisms by means of environmental factors. Referring, apparently, to Henderson's "Fitness of the Environment," he says: "It has been urged in a recent valuable work . . . that fitness is a reciprocal relation, involving

the environment no less than the organism. This is both a true and suggestive thought; but does it not leave the naturalist floundering amid the same old quicksands? The historical problem with which he has to deal must be grappled at closer quarters. He is everywhere confronted with specific devices in the organism that must have arisen long after the conditions of environment to which they are adjusted. Animals that live in water are provided with gills. Were this all, we could probably muddle along with the notion that gills are no more than lucky accidents. But we encounter a sticking point in the fact that gills are so often accompanied by a variety of ingenious devices, such as reservoirs, tubes, valves, pumps, strainers, scrubbing brushes, and the like, that are obviously tributary to the main function of breathing. Given water, asks the naturalist, how has all this come into existence and been perfected? The question is an inevitable product of our common sense." (Smithson. Inst. Rpt. for 1915, p. 405.)

Impressed with the difficulty of accounting for the phenomena of organic adaptation by means of the far too general and unspecific influence of the environment, the orthogenetic school of transformism inaugurated by Nägeli, Eimer, and Kölliker repudiated this explanation, and sought to explain organic evolution on the sole basis of internal factors, such as "directive principles," or germinal determinants. According to this conception, the elephant first developed his trunk under the drive of some internal agency, and afterwards sought out an environment in which the newly-developed trunk would be useful. In other words, orthogenesis makes the organ precede the function, and is therefore the exact reverse of Lamarckism.

Evolutionists in general, as we have said, regard our present plants and animals as the modified progeny of earlier forms, understanding by "modified" that which is the product of a trans-specific, as distinguished from a varietal or intra-specific, change. To substantiate the claim that changes of specific magnitude have actually taken place, they appeal to two principal kinds of evidence, namely: (a) empirical evidence based

on such variations as are now observed to occur among living organisms; (b) inferential evidence, which aposterioristically deduces the common ancestry of allied organic types from their resemblances and their sequence in geological time. Hence, if we omit as negligible certain subsidiary arguments, the whole evidence for organic evolution may be summed up under three heads: (1) the genetic evidence grounded on the facts of variation; (2) the zoölogical evidence based on homology, that is, on structural resemblance together with all further resemblances (physiological and embryological), which such similarity entails; (3) the palæontological evidence which rests on the gradual approximation of fossil types to modern types, when the former are ranged in a series corresponding to the alleged chronological order of their occurrence in the geological strata. It is the bearing of recent genetical research upon the first of these three lines of evidence that we propose to examine in the present chapter, an objective to which a brief and rather eclectic historical survey of evolutionary thought appears to offer the easiest avenue of approach.

While many bizarre speculations on the subject of transformism had been hazarded in centuries prior to the nineteenth, the history of this conception, as a scientific hypothesis, dates from the publication of Lamarck's "Philosophie Zoologique" in 1809. According to Lamarck, organic species are changed as a result of the *indirect* influence of the external conditions of life. A change in environment forces a change of habit on the part of the animal. A change in the animal's habits results in adaptation, that is, in the development or suppression of organs through use or disuse. The adaptation, therefore, thus acquired was not directly imposed by the environment, but only indirectly—that is, through the mediation of habit. Once acquired by the individual animal, however, the adaptation was, so Lamarck thought, taken up by the process of inheritance and perpetuated by being transmitted to the animal's offspring. The net result would be a progressive differentia-

tion of species due to this indirect influence of a varying environment.

Such was the theory of Lamarck, and it is sound and plausible in all respects save one, namely, the unwarranted assumption that acquired adaptations are inheritable, since these, to quote the words of the Harvard zoölogist, G. H. Parker, "are as a matter of fact just the class of changes in favor of the inheritance of which there is the least evidence." ("Biology and Social Problems," 1914, p. 103.)

The next contribution to the philosophy of transformism was made by Charles Darwin, when, in the year 1859, he published his celebrated "Origin of Species." In this work, the English naturalist bases the evolution of organic species upon the assumed spontaneous tendency of organisms to vary minutely from their normal type in every possible direction. This spontaneous variability gives rise to slight variations, some of which are advantageous, others disadvantageous to the organism. The enormous fecundity of organisms multiplies them in excess of the available food supply, and more, accordingly, are born than can possibly survive. In the ensuing competition or struggle for existence, individuals favorably modified survive and propagate their kind, those unfavorably modified perish without progeny. This process of elimination Darwin termed natural selection. Only individuals favored by it were privileged to propagate their kind, and thus it happened that these minute variations of a useful character were seized upon and perpetuated "by the strong principle of *inheritance*." In this way, these slight but useful modifications would tend gradually to accumulate from generation to generation in the direction favored by "natural selection," until, by the ensuing summation of innumerable minor differences verging in the same direction, a major difference would be produced. The end-result would be a progressive *divergence* of posterity from the common ancestral type, whence they originally sprang, ending in a multiplicity of new forms or species, all differing to a greater or lesser extent from

the primitive type. The contrary hypothesis of a possible *convergence* of two originally diverse types towards eventual similarity Darwin rejected as an extremely improbable explanation of the observed resemblance of organic forms, which, not without reason, he thought it more credible to ascribe to their assumed divergence from a common ancestral type.

Such was the scheme of evolution elaborated by Charles Darwin. His hypothesis leaves the origin of variations an unsolved mystery. It assumes what has never been proved, namely, the efficacy of "natural selection." It rests on what has been definitely disproved by factual evidence, namely, the inheritability of the slight variations, now called fluctuations, which, not being transmitted even, by the hereditary process, cannot possibly accumulate from generation to generation, as Darwin imagined. Moreover, fluctuations owe their origin to variability in the external conditions of life (*e.g.* in temperature, moisture, altitude, exposure, soil, food, etc.), being due to the *direct* influence or pressure of the environment, and not to any spontaneous tendency within the organism itself. Hence Darwin erred no less with respect to the spontaneity, than with respect to the inheritability and summation, of his "slight variations."

The subsequent history of Lamarckian and Darwinian Transformism is briefly told. That both should pass into the discard was inevitable, but, thanks to repeated revisions undertaken by loyal adherents, their demise was somewhat retarded. In vain, however, did the Neo-Darwinians attempt to do for Darwinism what the Neo-Lamarckians had as futilely striven to do for Lamarckism. The revisers succeeded only in precipitating a lethal duel between these two rival systems, which has proved disastrous to both. The controversy begun in 1891 between Herbert Spencer and August Weismann marked the climax of this fatal conflict.

Spencer refused to see any value whatever in Darwin's principle of natural selection, while other Neo-Lamarckians, less extreme, were content to relegate it to the status of a sub-

ordinate factor in evolution. Darwin had considered it "the most important means of modification," but it is safe to say that no modern biologist attaches very much importance to natural selection as a means of accounting for the differences which mark off one species from another. In fact, if natural selection has enjoyed, or still continues to enjoy, any vogue at all, it is not due to its value in natural science (which, for all practical intents and purposes, is nil), but solely to its appeal as "mechanistic solution"; for nothing further is needed to commend it to modern thinkers infected with what Wasmann calls *Theophobia*. Natural selection, in making the organism a product of the concurrence of blind forces unguided by Divine intelligence, a mere fortuitous result, and not the realization of purpose, has furnished the agnostic with a miserable pretext for omitting God from his attempted explanation of the universe. "Here is the knot," exclaims Du Bois-Reymond, "here the great difficulty that tortures the intellect which would understand the world. Whoever does not place all activity wholesale under the sway of Epicurean chance, whoever gives only his little finger to teleology, will inevitably arrive at Paley's discarded 'Natural Theology,' and so much the more necessarily, the more clearly he thinks and the more independent his judgment. . . . The possibility, ever so distant, of banishing from nature its seeming purpose, and putting a blind necessity everywhere in the place of final causes, appears, therefore, as one of the greatest advances in the world of thought, from which a new era will be dated in the treatment of these problems. To have somewhat eased the torture of the intellect which ponders over the world-problem will, as long as philosophical naturalists exist, be Charles Darwin's greatest title to glory." (*Darwin versus Galiani,* "Reden," Vol. I, p. 211.)

But however indispensable the selection principle may be to a philosophy which proposes to banish the Creator from creation, its scientific insolvency has become so painfully apparent that biologists have lost all confidence in its power to solve

the problem of organic origins. It is recognized, for example, that natural selection would suppress, rather than promote, development, seeing that organs have utility only in the state of perfection and are destitute of selection-value while in the imperfect state of transition. Again, the specific differences that diversify the various types of plants and animals are notoriously deficient in selection-value, and therefore the present differentiation of species cannot be accounted for by means of the principle of natural selection. Finally, unless one is prepared to make the preposterous assumption that the environment is a telic mechanism expressly designed for shaping organisms, he is under logical necessity of admitting that the influence of natural selection cannot be anything else than purely destructive. There is, as Wilson points out, no aprioristic ground for supposing that natural selection could do anything more than maintain the *status quo*, and as for factual proofs of its effectiveness in a positive sense, they are wholly wanting. Professor Caullery of the Sorbonne, in his Harvard lecture of Feb. 24, 1916, assures us that, "since the time of Darwin, natural selection has remained a purely speculative idea and that no one has been able to show its efficacy in concrete indisputable examples."

Considerations of this sort induced not only Neo-Lamarckians, but many non-partisans as well, to take the field against the Darwinian Selection Principle. Thus Spencer's caustic attack became a forerunner of others, and eminent biologists, like Fleischmann, Driesch, T. H. Morgan, and Bateson, have in turn poured the vials of their satire upon the attempts of Neo-Darwinians to rehabilitate the philosophy of natural selection. Wm. Bateson warns those, who persist in their credulity with reference to the Darwinian account of organic teleology, that they "will be wise henceforth to base this faith frankly on the impregnable rock of superstition and to abstain from direct appeals to natural fact." This admonition forms the conclusion of a scathing criticism of what he styles the "fustian of Victorian philosophy." "In the face of what we

know," it runs, "of the distribution of variability in nature, the scope claimed for natural selection must be greatly reduced. The doctrine of the survival of the fittest is undeniable so long as it is applied to the organism as a whole, but to attempt by this principle to find value in all definiteness of parts and functions, and in the name of science to see fitness everywhere, is mere eighteenth century optimism. Yet it was in its application to the parts, to the details of specific difference, to the spots on the peacock's tail, to the coloring of an orchid flower, and hosts of such examples, that the potency of natural selection was urged with greatest emphasis. Shorn of these pretensions the doctrine of the survival of favored races is a truism, helping scarcely at all to account for the diversity of species. Tolerance plays almost as considerable a part. By these admissions the last shred of that teleological fustian with which Victorian philosophy loved to clothe the theory of evolution is destroyed." (*Heredity*, "Presidential Address to Brit. Ass'n for Advanc. of Science," Aug. 14, 1914.) Nor is this all. The Darwinian Selection Principle is reproached with having retarded the progress of science. It is justly accused of having discouraged profound and painstaking analysis by putting into currency its shallow and spurious solution of biological problems. "Too often in the past," says Edmund Wilson, "the facile formulas of natural selection have been made use of to carry us lightly over the surface of unsuspected depths that would have richly repaid serious exploration." (Smithson. Inst. Rpt. for 1915, p. 406.)

In retaliation for the destructive criticism of natural selection, the Neo-Darwinians have proceeded to pulverize the Lamarckian tenet concerning the inheritability of acquired adaptations. Weismann, having laid down his classic distinction between the *soma* (comprising the vegetative or tissue cells in contact with the environment) and the *germ* (*i.e.* the sequestered reproductive cells or gametes, which are sheltered from environmental vicissitudes), showed that the Lamarckian assumption that a change in the somatic cells (which con-

stitute the organism of the individual) is registered in the germ cells (which constitute the vehicle of racial inheritance), is supported neither by *a priori* probability nor by any facts of observation. Germ cells give rise by division to somatic or tissue cells, but the converse is not true; for, once a cell has become differentiated and specialized into a tissue cell, it can never again give rise by division to germ cells, but only to other tissue cells of its own kind. Hence the possibility of a change in the tissue being transmitted to the germ has no antecedent probability in its favor. Neither is it grounded on the facts of observation. Bodily mutilations of the parent are not transmitted to the offspring. The child of a blacksmith is not born with a more developed right arm than that of a tailor's child. When the ovaries from a white rabbit are grafted into a black rabbit, whose own ovaries have been previously removed, the latter, if mated to a white male, will produce spotlessly white young. Hence the offspring inherit the characters of the germ track of the white female, whence the ovaries were derived, without being influenced in the least by the pigmented somatic cells of the nurse-body (*i.e.* the black female), into which the ovaries were grafted. Kammerer's experiments, in which young salamanders were found to exhibit at birth the coloration, which their parents had acquired through the action of sunlight, fail to convince, because, in this case, the bodies of the parents are not sufficiently impervious to light to preclude its direct action upon the gametes while in the reproductive organs of the parents. Hence we cannot be sure but that the coloration of the offspring derived from these gametes is due to the direct agency of sunlight rather than to the intermediate influence of the modified somatic cells upon the germ plasm.

The same objection holds true of the recent experiments, in which the germ cells have been modified by modifying the interior medium or internal environment by means of antibodies and hormones. No one doubts the possibility of influencing heredity by a direct modification of the germ cells, espe-

cially when, as is always the case in these experiments, the modification produced is destructive rather than constructive. The experiments, therefore, of Prof. M. F. Guyer of Wisconsin University, in which a germinally-transmitted eye defect was produced by injecting pregnant female rabbits with an anti-lens serum derived from fowls immunized to the crystalline lens of rabbits as antigen, are beside the mark. To demonstrate the Lamarckian thesis one must furnish evidence of a constructive addition to inheritance by means of prior somatic acquisition. The transmission of defects artificially produced is not so much a process of inheritance (transmission of type) as rather one of degeneracy (failure to equate the parental type).[1] Commenting on Guyer's suggestion that an organism capable of producing antibodies that are germinally-destructive, may also be able to produce constructive bodies, Prof. Edwin S. Goodrich says: "The real weakness of the theory is that it does not escape from the fundamental objections we have already put forward as fatal to Lamarckism. If an effect has been produced, either the supposed constructive substance was present from the first, as an ordinary internal environmental condition necessary for the normal development of the character, or it must have been introduced from without by the application of a new stimulus. The same objection does not apply to the destructive effect. No one doubts that if a factor could be destroyed by a hot needle or picked out with a fine forceps the effect of the operation would persist throughout subsequent generations." (*Science*, Dec. 2, 1921, p. 535.)

But in demonstrating against the Neo-Lamarckians that somatic modifications unrepresented in the germ plasm could have no significance in the process of racial evolution, Weismann had *proved too much*. His argument was no less telling

[1] A good definition of degeneracy is that of A. F. Tredgold, who says: "I venture to define degeneracy as 'a retrograde condition of the individual resulting from a pathological variation of the germ cell.'" (Smithson. Inst. Rpt. for 1918, p. 548.)

against Darwinism than it was against Lamarckism. Darwin's "individual differences" or "slight variations," now spoken of as fluctuations, were quite as unrepresented and unrecorded in the germ cells as Lamarck's "acquired adaptations." There can be no "summation of individual differences" for the simple reason that fluctuations have no germinal basis and are therefore uninheritable—"We must bear in mind the fact," says Prof. Edmund Wilson, "that Darwin often failed to distinguish between non-inheritable fluctuations and hereditary mutations of small degree." (Smithson. Inst. Rpt. for 1915, p. 406.) Fluctuations, as we have seen, are due to variability in the environmental conditions, *e.g.* in access to soil nutrients, etc. As an instance of fluctuational variation the seeds of the ragweed may be cited. Normally these seeds have six spines, but around this average there is considerable fluctuation in individual seeds, some having as many as nine spines and others no more than one. Yet the plants reared from nine-spine seeds, even when similarly mated, show no greater tendency to produce nine-spine seeds than do plants reared from one-spine seeds.

To meet the difficulty presented by the non-inheritability of the Lamarckian adaptation and the Darwinian fluctuation, De Vries substituted for them those rare and abruptly-appearing inheritable variations, which he called mutations [2] and regarded as elementary steps in the evolutionary process. This new version of transformism was announced by De Vries in 1901, and more fully explained in his "Die Mutations-Theorie" (Leipzig, 1902-1903). Renner has shown that De Vries' new forms of Œnothera were cases of complex hybridization rather than real mutants, as the forms produced by mutation are now called. Nevertheless, the work of Morgan, Bateson, and others leaves little doubt as to the actual occur-

[2] The term mutation had been used long before and in a similar sense by the German palæontologist Waagen, who employed it to designate the variations of a specific type that succeed one another in successive strata, a thing which rarely occurs. (Cf. Waagen's *Die Formenreihe des Ammonites subradiatus,* Geognost. paläont. Beitr., Berlin, 1869.)

rence of *factorial* mutants, while Dr. Albert F. Blakeslee has demonstrated the existence of *chromosomal* mutants. When unqualified, the term mutant usually denotes the factorial mutant, which arises from a change in one or more of the concatenated genes (hereditary factors) of a single chromosome (nuclear thread) in the germinal (*i.e.* gametic) complex. All such changes are called factorial mutations. They are hereditarily transmissible, and affect the somatic characters of the race permanently, although, in rare cases, such as that of the bar-eyed Drosophila mutant, the phenomenon of *reversion* has been observed. The chromosomal mutant, on the contrary, is not due to changes in the single factors or genes, but to duplication of one or more entire chromosomes (linkage-groups) in the gametic complex. Like the factorial mutant, it produces a permanent and heritable modification. The increase in nuclear material involved in chromosomal mutation (*i.e.* duplication) seems to cause a proportionate increase in the cytoplasmic mass of the single somatic cells, which manifests itself in the phenotype as giantism. De Vries' *Œnothera gigas* is a chromosomal mutant illustrative of this phenomenon. Besides the foregoing, there is the *pseudomutant* produced by the factorial recombination, which results from a *crossover, i.e.* an exchange of genes or factors between two germinal chromosomes of the same synaptic pair. This reciprocal transfer of genes from one homologous chromosome to another happens, in a certain percentage of cases, during synapsis. The percentage can be artificially increased by exposing young female hybrids to special conditions of temperature.

If these new mutant forms could be regarded as genuine new species, then the fact that such variations are heritable and come within the range of actual observation, would constitute the long-sought empirical proof of the reality of evolution. Consciously or subconsciously, however, De Vries recognized that this was not the case; for he refers to mutants as "elementary species," and does not venture to present them as authentic organic species.

The factorial mutant answers neither the endurance test nor the intersterility test of a genuine species. It would, doubtless, be going too far to regard all such mutant forms as examples of germinal degeneracy, but it cannot be denied that all of them, when compared to the wild type, are in the direction of unfitness, none of them being viable and prosperous under the severe conditions obtaining in the wild state. Bateson, who seems to regard all mutant characters as recessive and due to germinal loss, declares: "Even in Drosophila, where hundreds of genetically distinct factors have been identified, very few new dominants, that is to say positive additions, have been seen, and I am assured that none of them are of a class which could be expected to be viable under natural conditions. I understand even that none are certainly viable in the homozygous state." (Toronto Address, *Science,* Jan. 20, 1922, p. 59.) "Garden or greenhouse products," says D. S. Jordan, "are immensely interesting and instructive, but they throw little light on the origin of species. To call them species is like calling dress-parade cadets 'soldiers.' I have heard this definition of a soldier, 'one that has stood.' It is easy to trick out a group of boys to look like soldiers, but you can not define them as such until they have 'stood.'" (*Science,* Oct. 20, 1922.) In a word, factorial mutants, owing, as they do, their survival exclusively to the protection of artificial conditions, could never become the hardy pioneers of new species.

Bateson insists that the mutational variation represents a change of loss. "Almost all that we have seen," he says, "are variations in which we recognize that elements have been lost." (*Science,* Jan. 20, 1922, p. 59.) In his Address to the British Association (1914), he cites numerous examples tending to show that mutant characters are but diminutions or intensifications of characters pre-existent in the wild or normal stock, all of which are explicable as effects of the loss (total or partial) of either positive, or inhibitive (epistatic) hereditary factors (genes). One of these instances illustrating the

subtractive nature of the factorial mutation is that of the Primula "Coral King," a salmon-colored mutant, which was suddenly given off by a red variety of Primula called "Crimson King." Such a mutation is obviously based on the loss of a germinal factor for color. The loss, however, is sometimes partial rather than total, as instanced in the case of the purple-edged Picotee sweet pea, which arose from the wholly purple wild variety by fractionation of the genetic factor for purple pigment. Even where the mutational variation appears to be one of gain, as happens when a positive character appears *de novo* in the phenotype, or when a dilute parental character is intensified in the offspring, it is, nevertheless, interpretable as a result of germinal loss, the loss, namely, total or partial, of a genetic inhibitor. Such inhibitive genes or factors are known to exist. Bateson has shown, for example, that the whiteness of White Leghorn chickens is due, not to the absence of color-factors, but to the presence of a genetic inhibitor—"The white of White Leghorns," he says, "is not, as white in nature often is, due to the loss of the color elements, but to the action of something which inhibits their expression." (Address to the Brit. Ass'n, Smithson. Inst. Rpt. for 1915, p. 368.) Thus the sudden appearance in the offspring of a character not visibly represented in the parents may be due, not to germinal acquisition, but the loss of an inhibitory gene, whose elimination allows the somatic character previously suppressed by it to appear. Hence Bateson concludes: "In spite of seeming perversity, therefore, we have to admit that there is no evolutionary change which in the present state of our knowledge we can positively declare to be not due to loss." (*Loc. cit.*, p. 375.)

Another consideration, which disqualifies the factorial mutant for the rôle of a new species, is its failure to pass the test of interspecific sterility. When individuals from two distinct species are crossed, the offspring of the cross is either completely sterile, as instanced in the mule, or at least partially so. But when, for example, the sepia-eyed mutant of the vinegar fly is

back-crossed with the red-eyed wild type, whence it originally sprang, the product of the cross is a red-eyed hybrid, which is perfectly fertile with other sepia-wild hybrids, with wild flies, and with sepia mutants. This proves that the sepia-eyed mutant has departed, so to speak, only a varietal, and not a specific, distance away from the parent stock. Ordinary or factorial mutation does not, therefore, as De Vries imagined, produce new species. These mutants do, indeed, meet the requirement of permanent transmissibility, for their distinctive characters cannot be obliterated by any amount of crossing. Nevertheless, the factorial mutation falls short of being an empirical proof of evolution, because it is a varietal, and not a specific, change. In other words, factorial mutants are new varieties and not new species. Only a heritable change based on germinal acquisition of sufficient magnitude to produce gametic incompatibility between the variant and the parent type would constitute direct evidence of the transmutation of species, provided, of course, that the variant were also capable of survival under the natural conditions of the wild state.

In his Toronto address of December 28, 1921, Wm. Bateson announced the failure of De Vries' Mutation Theory, when he said: "But that particular and essential bit of the theory of evolution, which is concerned with the origin and nature of species remains utterly mysterious. We no longer feel as we used to do, that the process of variation, now contemporaneously occurring, is the beginning of a work which needs merely the element of time for its completion; for even time cannot complete that which has not yet begun. The conclusion in which we were brought up that species are a product of a summation of variations ignored the chief attribute of species first pointed out by John Ray that the product of their crosses is frequently sterile in greater or less degree. Huxley, very early in the debate, pointed out this grave defect in the evidence, but before breeding researches had been made on a large scale no one felt the objection to be serious. Extended

work might be trusted to supply the deficiency. It has not done so, and the significance of the negative evidence can no longer be denied. . . .

"If species have a common origin where did they pick up the ingredients which produce this sexual incompatibility? Almost certainly it is a variation in which something has been added. We have come to see that variations can very commonly—I do not say always—be distinguished as positive and negative. . . . Now we have no difficulty in finding evidence of variation by loss, but variations by addition are rarities, even if there are any such which must be so accounted. The variations to which interspecific sterility is due are obviously variations in which something is apparently added to the stock of ingredients. It is one of the common experiences of the breeder that when a hybrid is partially sterile, and from it any fertile offspring can be obtained, the sterility, once lost, disappears. This has been the history of many, perhaps most, of our cultivated plants of hybrid origin.

"The production of an indubitably sterile hybrid from completely fertile parents which has arisen under critical observation is the event for which we wait. Until this event is witnessed, our knowledge of evolution is incomplete in a vital respect. From time to time such an observation is published, but none has yet survived criticism." (*Science*, Jan. 20, 1922, pp. 58, 59.)

But what of the chromosomal mutant? For our knowledge of this type of mutation we are largely indebted to Blakeslee's researches and experiments on the Jimson weed (*Datura stramonium*). According to Blakeslee, chromosomal mutants result from duplication, or from reduction, of the chromosomes, and they are classified as *balanced* or *unbalanced* types according as all, or only some, of the chromosomal linkage-groups are similarly doubled or reduced. If only one of the homologous chromosomes of a synaptic pair is doubled, the mutant is termed a *triploid* form. It is balanced when one homologous chromosome is doubled in every synaptic

pair, but if one or more chromosomes be added to, or subtracted from, this balanced triploid complex, the mutant is termed an unbalanced triploid. When all the chromosomes of the normal diploid complex are uniformly doubled, we have a balanced *tetraploid* race. The subtraction or addition of one or more chromosomes in the case of a balanced tetraploid complex renders it an unbalanced tetraploid mutant. The retention in somatic cells of the haploid number of chromosomes characteristic of gametes and gametophytes gives a balanced *haploid* mutant, from which hitherto no unbalanced haploids have been obtained. The normal diploid type and the balanced tetraploid type are said to constitute an *even* balance, while balanced triploids and haploids constitute an *odd* balance. The odd balances and all the unbalanced mutants are largely sterile. Thus, for example, more than 80% of the pollen of the haploid mutant is bad. "The normal Jimson Weed," says Blakeslee, "is diploid(2n) with a total of 24 chromosomes in somatic cells. In previous papers the finding of tetraploids(4n) with 48 chromosomes and triploids (3n) with 36 was reported, as well as unbalanced mutants with 25 chromosomes represented by the formula $(2n + 1)$. The finding of two haploid or 1n plants, which we are now able to report, adds a new chromosomal type to the balanced series of mutants in *Datura*. This series now stands: 1n, 2n, 3n, 4n. Since a series of unbalanced mutants has been obtained from each of the other balanced types by the addition or subtraction of one or more chromosomes, it is possible that a similar series of unbalanced mutants may be obtainable from our new haploid plants, despite the great unbalance which would thereby result." (*Science*, June 16, 1923, p. 646.) The haploid mutant, of which Blakeslee speaks, has, of course, 12 unpaired chromosomes in its somatic cells.

The balanced triploid is, like the haploid mutant, largely sterile, and is only obtainable by crossing the tetraploid race with the normal diploid plant. Since, then, the product of the cross of the diploid and tetraploid races is sterile, the

tetraploid race fulfills the sterility test of a distinct species. Whether or not it fulfills the endurance test of survival under natural condition is doubtful, inasmuch as diploid Daturas are about three times as prolific as the tetraploid race. Moreover, as Blakeslee himself confessed in a lecture at Woods Hole attended by the present writer in the summer of 1923, the origin of a balanced tetraploid form from the normal diploid type by simultaneous duplication of all the chromosomes in the diploid complex, is an event that has yet to be witnessed. Nor is any gradual transition from the diploid to the tetraploid race, by way of unbalanced types and triploids, conceivable, seeing that such forms are too sterile to maintain themselves, and are, in fact, incapable of transmitting their own type in the absence of artificial intervention. There are, it is true, some instances, in which diploid and tetraploid races and species occur together in cultivation and in nature. In certain cases, this tetraploidy is merely apparent, being due to fragmentation of the chromosomes; in other cases, it is really due to chromosomal duplication, giving rise to genuine tetraploid forms. The question is often hard to decide, the mere number of the chromosomes being not, in itself, a safe criterion. Of the actual origin, however, of tetraploid from diploid races we have as yet no observational evidence. Hence Blakeslee's researches on the chromosomal mutant have so far failed to furnish experimental proof of the origin of a genuine new species. Besides, waiving all other considerations, the limits within which chromosomal duplication is possible are of necessity so narrow, that, at best, this phenomenon can only be invoked to explain a very small range of variation. In fact, it is doubtful whether haploidy, triploidy, and tetraploidy have any important bearing whatever upon the problem of the origin of species.

The mutation, then, in so far as we have experimental knowledge of it, does not fulfill requirements of a specific change. It cannot even be regarded as an *elementary step* in the direction of such a change. With this admission, De-

Vriesianism becomes obsolete, descending like its predecessors, Lamarckism and Darwinism, into the charnel-house of discarded systems whose value is historic, but no longer scientific. When we enquire into the reason of this common demise of all the classic systems of transformism, we find it to reside in the progress of the new science of Mendelian genetics, whose foundations were laid by an Augustinian monk of the nineteenth century. Six years after the appearance of Darwin's "Origin of Species," Gregor Johann Mendel published a short paper entitled "Versuche über Pflanzenhybriden," which, unnoticed at the time by a scientific world preoccupied with Darwinian fantasies, was destined, on its coming to light at the beginning of the present century, to administer the final *coup de grace* to all the elaborate schemes of evolution that had preceded or followed its initial publication. It took half a century, however, before the dust of Darwinian sensationalism subsided sufficiently, to permit the "rediscovery" of Mendel's solid and genuine contribution to biological science. But the Prälat of the abbey at Brünn never lived to see the day of his triumph. The true genius of his century, he died unhonored and unsung, a pretender being crowned in his stead. For Coulter says of Darwin: "He died April 19, 1882, probably the most honored scientific man in the world." (*Evolution*, 1916, p. 35.)

Within the small dimensions of the paper, of which we have spoken, Mendel had compressed the results of years of carefully conceived and accurately executed experimentation reduced to precise statistical form and interpreted with a penetrating sagacity of the highest order. It is no exaggeration to say that his discovery has revolutionized the science of biology, giving it, for the first time, mathematical formulas comparable to those of chemistry. His two laws of inheritance, namely, the law of segregation and the law of independent assortment of characters, have, as previously intimated, become the basis of the new science of Genetics. His analysis of biparental reproduction has interpreted for us the

cytological phenomena of synapsis, meiosis, and syngamy, has explained for us the instability of hybrids, has placed Weismann's speculations concerning the autonomy and continuity of the germ plasm on a firm basis of experimental fact, has clarified all our notions respecting the mode and range of hereditary transmission, and has, in a word, opened our eyes to that new and hitherto unexplored realm of nature which Bateson calls "the world of gametes."

Efforts have been made to construct systems of transformism along Mendelian lines, but none of them has met with notable success. Lotsy, for example, sought to explain all variation on the basis of the rearrangement of preëxistent genetic factors brought about by crossing. But such a solution of the problem is very unsatisfactory. In the first place, the generality of hybrid (heterozygous) forms are ruled out on the score of instability. The phenotype of hybrids is directly dependent, not on the genes themselves, but on the diploid combination of genes contained in the zygote. This combination, however, is always dissolved in the process of gamete-formation, by the segregative reduction division which occurs in the reproductive organs of the hybrid. Hybrids, therefore, do not *breed true,* if propagated by sexual reproduction. To maintain constancy of type in hybrids, one must resort to somatogenic reproduction (*i.e.* vegetative growth from stems, etc.). Certain violets, in fact, as well as blackberries, are maintained in a state of constant hybridism by means of this sort of reproduction, even in nature. In the case of *balanced lethals* (*i.e.* factors causing death in the pure or homozygous state), the hybrid phenotype may be maintained even by sexual reproduction, inasmuch as all the pure (homozygous) offspring are non-viable. Two lethals are said to be balanced, when they occur, the first in one and the second in the other homologous chromosome of the same synaptic pair. "Such a factorial situation would maintain a state of constant heterozygosis, the fixed hybridism of an impure species . . . the hybrid will breed true until the relative position of the

lethals are changed by a crossover, or the genetical constitution in these respects is altered by a mutation." (Davis, *Science,* Feb. 3, 1922, p. 111.) As is evident, however, the condition of balanced lethals involves a considerable reduction in fertility.

Hybridization, moreover, is successful between varieties of the same species rather than between distinct species. Interspecific crosses are in some cases entirely unproductive, in other cases productive of wholly-sterile, hybrids, and in still other cases productive of semisterile hybrids. When semisterile hybrids are obtainable from an interspecific cross, the phenotype can be kept constant by somatogenic reproduction, but, as we shall see in a later chapter, this kind of reproduction does not counteract senescence, and stock thus propagated usually plays out within a determinate period. Finally, the mixture of incompatible germinal elements involved in an interspecific cross tends to produce forms, which are subnormal in their viability and vitality. The conclusions of Goodspeed and Clausen are the following: "(1) As a consequence of modern Mendelian developments, the Mendelian factors may be considered as making up a reaction system, the elements of which exhibit more or less specific relations to one another; (2) strictly Mendelian results are to be expected only when the contrast is between factor differences within a common Mendelian reaction system as is ordinarily the case in varietal hybrids; (3) when distinct reaction systems are involved, as in species crosses, the phenomena must be viewed in the light of a contrast between systems rather than between specific factor differences, and the results will depend upon the degree of mutual compatibility displayed between the specific elements of the two systems." (*Amer. Nat.,* 51 (1917), p. 99.) To these conclusions may be added the pertinent observation of Bradley Moore Davis: "Of particular import," he says, "is the expectation that lethals most frequently owe their presence to the heterozygous condition since the mixing of diverse germ plasms seems likely to lead to the breaking down of delicate

and vital adjustments in proportion relative to the degree of protoplasmic confusion, and this means chemical and physical disturbance." (*Science,* Feb. 3, 1923, p. 111.)

But crossing produces, in the second filial generation (F_2), pure (homozygous) as well as hybrid (heterozygous) forms. In some cases these pure forms are new, the phenotype being different from that of either pure grandparent. Such a result is produced by *random assortment* of the chromosomes in gamete and zygote formation, and occurs when the genes for two or more pairs of contrasted characters are located in different chromosome pairs. The phenomenon is formulated in Mendel's Second Law, the law of independent assortment. The novelty, however, of the true-breeding forms thus produced is not absolute, but relative. There is no origination of new hereditary factors. It is simply a recombination of the old genes of different stocks, the genes themselves undergoing no intrinsic alteration. The combination is new, but not the elements combined. In addition to chromosomal recombination, we have factorial recombination by means of crossovers. This, too, can produce new and true-breeding forms of a fixed nature, but here, likewise, it is the combination, and not the elements combined, which is new. The "new" forms thus produced are called, as we have seen, pseudomutants. When pseudomutations, that is, crossovers, occur in conjunction with the condition of balanced lethals, they closely simulate genuine factorial mutations. This is exemplified in the case of De Vries' *Œnothera Lamarckiana,* which is the product of a crossover supervening upon a situation of balanced lethals. In cases of this kind, the crossover releases hitherto suppressed recessive characters, giving the appearance of real mutation. "The workers with Drosophila," says Davis, "seem inclined to believe that much of the phenomena simulating mutation in their material is in reality the appearance of characters set free by the breaking of lethal adjustments which held the characters latent. Well-known workers have arrived at similar conclusions for *Œnothera* material and are not content to

accept as evidence of mutations the behavior of *Lamarckiana* and some other forms when they throw their marked variants." (*Science,* Feb. 3, 1922, p. 111.)

The new forms, however, resulting from random assortment and crossovers cannot be regarded as new species. "Analysis," says Bateson, "has revealed hosts of transferable characters. Their combinations suffice to supply in abundance series of types which might pass for new species, and certainly would be so classed if they were met with in nature. Yet critically tested, we find that they are not distinct species and we have no reason to suppose any accumulation of characters of the same order would culminate in the production of distinct species. Specific difference therefore must be regarded as probably attaching to the base upon which these transferables are implanted, of which we know absolutely nothing at all. Nothing that we have witnessed in the contemporary world can colorably be interpreted as providing the sort of evidence required." (*Science,* Jan. 20, 1922, pp. 59, 60.)

Anyone thoroughly acquainted with the results of genetical analysis and research will find it impossible to escape the conviction that there is no such thing as experimental evidence for evolution. In spite of the enormous advances made in the fields of genetics and cytology, the problem of the origin of species is, scientifically speaking, as mysterious as ever. No variation of which we have experience is interpretable as the transmutation of a specific type, and David Starr Jordan voices an inevitable conclusion when he says: "None of the created 'new species' of plant or animal I know of would last five years in the open, nor is there the slightest evidence that any new species of field or forest or ocean ever originated from mutation, discontinuous variation, or hybridization." (*Science,* Oct. 20, 1922, p. 448.)

"In any case," as Professor Caullery tells us in his Harvard lecture on the "Problem of Evolution," "we do not see in the facts emerging from Mendelism, how evolution, in the sense that morphology suggests, can have come about. And it

comes to pass that some of the biologists of greatest authority in the study of Mendelian heredity are led, with regard to evolution, either to a more or less complete agnosticism, or to the expression of ideas quite opposed to those of the preceding generation; ideas which would almost take us back to creationism." (Smithson. Inst. Rpt. for 1916, p. 334.) It is, of course, impossible within the limits of a single chapter to convey any adequate impression of all that Mendel's epoch-making achievement portends, but what has been said is sufficient to give some idea of the acuteness of the crisis through which the theory of organic evolution is passing as a result of his discovery. In its classic forms of Lamarckism, Darwinism and De-Vriesianism, the survival of the theory is out of the question. Whether or not it can be rehabilitated in any form whatever is a matter open to doubt. Transfixed by the innumerable spears of modern objections, its extremity calls to mind the plight of the Lion of Lucerne. Possibly, it is destined to find a rescuer in some great genius of the future, but of one thing, at least, we may be perfectly certain, namely, that, even if rejuvenated, it will never again resume the lineaments traced by Charles Darwin. In the face of this certainty, it is almost pitiful to hear the die-hards of Darwinism bolstering up a lost cause with the wretched quibble that, though natural selection has been discredited as an explanation of the differentiation of species, Darwinism "in its essentials" survives intact. For, if there is any feature which, beyond all else, deserves to be called an essential of Darwin's system, surely it is natural selection. For Darwin it was "the most important" agency of transformation (cf. "Origin of Species," 6th ed., p. 5). Apart from his hypothesis of the summation through inheritance of slight variations ("fluctuations"), now completely demolished by the new science of genetics, it represented his sole contribution to the philosophy of transformism. It alone distinguishes Darwinism from Lamarckism, its prototype. Without it the "Origin of Species" would be Hamlet without the Prince of Denmark. With it

Darwin's fame should stand or fall. Therefore, since Darwin erred in making it "the most important means of modification," Darwinism is dead, and no grief of mourners can resuscitate the corpse. "Through the last fifty years," says Bateson, "this theme of the natural selection of favored races has been developed and expounded in writings innumerable. Favored races certainly can replace others. The argument is sound, but we are doubtful of its value. For us that debate stands adjourned. We go to Darwin for his incomparable collection of facts. We would fain emulate his scholarship, his width, and his power of exposition, but to us he speaks no more with philosophical authority. We read his scheme of evolution as we would those of Lucretius or of Lamarck, delighting in their simplicity and their courage." (*Heredity*, Presid. Add. to British Assoc. for Advanc. of Science, Smith. Inst. Rpt. for 1915, p. 365.)

CHAPTER II

HOMOLOGY AND ITS EVOLUTIONARY INTERPRETATION

The recent revival of interest in the problem of evolution seems to have called forth two very opposite expressions of opinion from those who profess to represent Catholic thought on this subject. M. Henri de Dorlodot, in his "Le Darwinisme," appears in the rôle of an ardent admirer of Darwin and an enthusiastic advocate of the doctrine of Transformism. The contrary attitude is adopted by Mr. Alfred McCann, whose "God—or Gorilla" is bitterly antagonistic not only to Darwinism but to any form whatever of the theory of Transformism. Both of these works possess merits which it would be unjust to overlook. Dorlodot deserves credit for having shown conclusively that there is absolutely nothing in the Scriptures, or in Patristic tradition, or in Catholic theology, or in the philosophy of the Schools, which conflicts with our acceptance of organic evolution as an hypothesis explanatory of certain biological facts. In like manner, it must be acknowledged that, even after a liberal discount has been made in penalty of its bias and scientific inaccuracy, Mr. McCann's book still contains a formidable residue of serious objections, which the friends of evolution will probably find it more convenient to sidestep than to answer.

Unfortunately, however, neither of these writers maintains that balanced mental poise which one likes to see in the defenders of Catholic truth. Dorlodot seems too profoundly impressed with the desirability of occupying a popular position to do impartial justice to the problem at issue, and his anxiety to keep in step with the majority blinds him apparently

to the flaws of that "Darwinism" which he praises. Had he been content with a simple demarcation of negative limits, there would be no ground for complaint. But, when he goes so far as to bestow unmerited praise upon the author of the mechanistic "Origin of Species" and the materialistic "Descent of Man"; when, by confounding Darwinism with evolution, he consents to that historical injustice which allows Darwin to play Jacob to Lamarck's Esau, and which leaves the original genius of Mendel in obscurity while it accords the limelight of fame to the unoriginal expounder of a borrowed conception; when, by means of the sophistry of anachronism, he speciously endeavors to bring the speculations of an Augustine or an Aquinas into alignment with those of the ex-divinity student of Cambridge; when he assumes that Fixism is so evidently wrong that its claims are unworthy of consideration, whereas Transformism is so evidently right that we can dispense with the formality of examining its credentials; when, in a word, he expresses himself not merely in the sense, but in the very stereotyped cant phrases of a dead philosophy, we realize, with regret, that his conclusions are based, not on any reasoned analysis of the evidence, but solely upon the dogmatism of scientific orthodoxy, that his thought is cast in antiquated molds, and that for him, apparently, the sixty-five years of discovery and disillusionment, which have intervened since the publication of the "Origin of Species," have passed in vain.

But, if Dorlodot represents the extreme of uncritical approval, Mr. McCann represents the opposite, and no less reprehensible, extreme of biased antagonism, that is neither fair in method nor conciliatory in tone. Instead of adhering to the time-honored practice of Catholic controversialists, which is rather to overstate than to understate the argument of an adversary, Mr. McCann tends, at times, to minimize, in his restatement, the force of an opponent's reasoning. He frequently belittles with mere flippant sneer, and is only too ready to question the good faith of those who do not share his con-

victions. Thus, when McCann ridicules Wells and accuses him of pure romancing, because the latter speaks of certain hairy "wild women" of the Caves, he himself seems to be ignorant of the fact that a palæolithic etching has been found representing a woman so covered with hair that she had no need of other apparel (the bas-relief from Laugerie-Basse carved on reindeer palm—cf. Smithson. Inst. Rpt. for 1909, p. 540 and Plate 2).

Mr. McCann may object, with truth, that this is far from being a proof that the primitive representatives of the human race were hairy individuals, but the fact suffices, at least, to acquit Mr. Wells of the charge of unscrupulous invention. Hence, while we have no wish to excuse the lamentable lack of scientific conscientiousness so manifestly apparent in the writings of popularizers of evolution, like Wells, Osborn, and Haeckel, nevertheless common justice, not to speak of charity, constrains us to presume that, occasionally at least, their departures from the norm of objective fact were due to ordinary human fallibility or to the mental blindness induced by preconceptions, rather than to any deliberate intent to deceive. And we feel ourselves impelled to make this allowance for unconscious inaccuracy all the more readily that we are confronted with the necessity of extending the selfsame indulgence to Mr. McCann himself. Thus we find that the seventh illustration in "God—or Gorilla" (opposite p. 56) bears the legend: "Skeletons of man and *chimpanzee* compared," when, in point of fact, the ape skeleton in question is not that of a chimpanzee (*Troglodytes niger*) at all, but of an Orang-utan (*Simia satyrus*), as the reader may verify for himself by consulting Plate VI of the English version of Wasmann's "Modern Biology," where the identical illustration appears above its proper title: "Skeleton of an adult Orang-utan." Since the error is repeated in the index of illustrations and in the legend of the third illustration of the appendix, it is impossible, in this instance, to shift the responsibility from Mr. McCann to the printer. In any case, it is sincerely to be hoped that this,

and several other infelicitous errors will be rectified in the next edition of "God—or Gorilla."

In the next chapter we shall have occasion to refer again to Dorlodot's book. For the present, however, his work need not concern us, while in that of Mr. McCann we single out but one point as germane to our subject, namely, the latter's inadequate rebuttal of the evolutionary argument from homology. The futility of his method, which consists in matching insignificant differences against preponderant resemblances, and in exclaiming with ironic incredulity: "Note extraordinary resemblances!" becomes painfully evident, so soon as proper presentation enables us to appreciate the true force of the argument he is striving to refute. *Functionally* the foot of a Troglodyte ape may be a "hand," but *structurally* it is the homologue of the human foot, and not of the human hand; nor is this homology effectually disposed of by stressing the dissimilarity of the hallux, whilst one remains discreetly reticent concerning the similarity of the calcaneum. For two reasons, therefore, the irrelevance of Mr. McCann's reply is of special interest here: (1) because it illustrates concretely the danger of rendering a refutation inconsequential and inept by failing to plumb the full depth of the difficulty one is seeking to solve; (2) because it shows that it is vain to attempt to remove man's body from the scope of this argument by citing the inconsiderable structural differences which distinguish him from the ape, so that, unless the argument from homology proves upon closer scrutiny to be inherently *inconclusive,* its applicability to the human body is a foregone conclusion, and implies with irresistible logic the common ancestry of men and apes.

Such are the reflections suggested by the meager measure of justice which Mr. McCann accords to the strongest zoölogical evidence in favor of evolution, and they contain in germ a feasible program for the present chapter, which, accordingly, will address itself: first, to the task of ascertaining the true significance of homology in the abstract as well as the full extent of its application in the concrete; second, to that of

determining with critical precision its intrinsic value as an argument for the theory of transmutation.

Homology is a technical term used by the systematists of botany, zoölogy and comparative anatomy to signify basic structural similarity as distinguished from superficial functional similarity, the latter being termed *analogy*. Organisms are said to exemplify the phenomenon of homology when, beneath a certain amount of external diversity, they possess in common a group of correlated internal resemblances of such a nature that the organisms possessing them appear to be constructed upon the same fundamental plan. In cases of this kind, the basic similarity is frequently masked by a veneer of unlikeness, and it is only below this shallow surface of divergence that we find evidences of the identical structure or common type.

Thus organs of different animals are said to be homologous when they are composed of like parts arranged in similar relation to one another. Homologous organs correspond bone for bone and tissue for tissue, so that each component of the one finds its respective counterpart in the other. The organs in question may be functionally specialized and externally differentiated for quite different purposes, but the superficial diversity serves only to emphasize, by contrast, the underlying identity of structure which persists intact beneath it. Thus, for example, the wing of a pigeon, the flipper of a whale, the foreleg of a cat, and the arm of a man are organs differing widely in function as well as outward appearance, but they are called homologous, none the less, because they all exhibit the same basic plan, being composed of similar bones similarly disposed with respect to one another.

Organs, on the other hand, are called analogous which, though fundamentally unlike in structure, are, nevertheless, superficially modified and specialized for one and the same function. The wing of a bird and the wing of an insect furnish a trite instance of such analogy. Functionally they subserve the same purpose, but structurally they bear no relation to

each other. In like manner, though both are devoted to the same function, there exists between the leg of a man and the leg of a spider a fundamental disparity in structure.

At times, specialization for the selfsame function involves the emergence of a similar modification or uniform structural adaptation from a substrate of basic dissimilarity. In these instances of parallel modifications appearing on the surface of divergent types, we have something more than mere functional resemblance. Structure is likewise involved, albeit superficially, in the modification which brings about this external uniformity. In such cases, analogy is spoken of as *convergence,* a phenomenon of which the mole and the mole-cricket constitute a typical example. The burrowing legs of the insect are, so far as outward appearance goes, the exact replica on a smaller scale of those of the mole, though, fundamentally, their structure is quite unlike, the mole being built on the endoskeletal plan of the vertebrates, whereas the mole-cricket is constructed on the exoskeletal plan characteristic of the arthropods. Speaking of the first pair of legs of the mole-cricket, Thomas Hunt Morgan says: "By their use the mole-cricket makes a burrow near the surface of the ground, similar to, but of course much smaller than, that made by the mole. In both of these cases the adaptation is the more obvious, because, while the leg of the mole is formed on the same general plan as that of other vertebrates, and the leg of the mole-cricket has the same fundamental structure as that of other insects, yet in both cases the details of structure and the general proportions have been so altered that the leg is fitted for entirely different purposes from those to which the legs of other vertebrates and other insects are put." (Quoted by Dwight in "Thoughts of a Catholic Anatomist," p. 235.) In the analogies of convergence, therefore, we have the exact converse of the phenomenon so often encountered in connection with homology. The latter exhibits a contrast between basic identity and superficial diversity, the former a contrast between superficial convergence and fundamental divergence.

Now the extreme importance of homology is manifest from the fact that the taxonomists of zoölogy and botany have found it to be the most satisfactory basis for a scientific classification of animals and plants. In both of these sciences, organisms are arranged in groups according as they possess in common certain points of resemblance whereby they may be referred to this, or that, general type. The resemblance is most complete between members of the same species, which do not differ from one another by any major difference, though they may exhibit certain minor differences justifying their subdivision into varieties or races. These morphological considerations, however, must, in the case of an organic species, be supplemented by the additional physiological criteria of perfect sexual compatibility and normal viability, as we have already had occasion to note in the previous chapter. When organisms, though distinguished from one another by some major difference, agree, notwithstanding, in the main elements of structure, the several species to which they belong are grouped under a common genus, and similarly genera are grouped into families. A *relative* major difference, such as a difference in the size of the teeth, suffices for the segregation of a new species, while an *absolute* difference, such as a difference in the number of teeth or the possession of an additional organ, suffices for the segregation of a new genus. In practice, however, the classifications of systematists are often very arbitrary, and we find the latter divided into two factions, the "lumpers" who wish to reduce the number of systematic groups and the "splitters" who have a passion for breaking up larger groups into smaller ones on the basis of tenuous differences. Above the families are the orders, and they, in turn, are assembled in still larger groups called classes, until finally we reach the phyla or branches, which are the supreme categories into which the plant and animal kingdoms are divided. As we ascend the scale of classification, the points of resemblance between the organisms classified are constantly decreasing in number, while the points of difference increase apace. Hence,

whereas members of the same species have very much in common, members of the same phylum have very little in common, and members of different phyla show such structural disparity that further correlation on the basis of similarities becomes impossible (in the sense, at least, of a reliable and consistent scheme of classification), all efforts to relate the primary phyla to one another in a satisfactory manner having proved abortive.

Within the confines of each phylum, however, homology is the basic principle of classification. But the scientist is not content to note the bare fact of its existence. He seeks an explanation, he wishes to know the *raison d'être* of homology. Innumerable threads of similarity run through the woof of divergence, and the question arises: How can we account for the coëxistence of this woof of diversity with a warp of similarity? Certainly, if called upon to explain the similarity existent between members of one and the same species, even the man in the street would resort instinctively to the principle of inheritance and the assumption of common ancestry, exclaiming: "Like sire, like son!" It is a notorious fact that children resemble their parents, and since members of the same species are sexually compatible and perfectly interfertile, there is no difficulty whatever in the way of accepting the presumption of descent from common ancestral stock as a satisfactory solution of the problem of specific resemblance. Now, it is precisely this selfsame principle of heredity which the Transformist invokes to account for generic, no less than for specific, similarity. In fact, he presses it further still, and professes to see therein the explanation of the resemblances observed between members of the different families, orders, and classes, which systematists group under a common phylum. This, of course, amounts to a bold extension of the principle of inheritance far beyond the barriers of interspecific sterility to remote applications that exceed all possibility of experimental verification. Transformists answer this difficulty, however, by contending that the period, during which the human race has existed, has been,

geologically speaking, all too brief, and characterized by environmental conditions much too uniform, to afford us a favorable opportunity for ascertaining the extreme limits to which the genetic process may possibly extend; and, even apart from this consideration, they say, racial development (phylogeny) may be, like embryological development (ontogeny) an irreversible process, in which case no recurrence whatever of its past phenomena are to be expected in our times.

Be that as it may, the evolutionist interprets the resemblances of homology as surviving vestiges of an ancient ancestral type, which have managed to persist in the descendants notwithstanding the transformations wrought in the latter by the process of progressive divergence. Moreover, just as the existence of a common ancestor is inferred from the *fact* of resemblance, so the relative position in time of the common ancestor is inferred from the *degree* of resemblance. The common ancestor of forms closely allied is assumed to have been proximate, that of forms but distantly resembling each other is thought to have been remote. Thus the common ancestor of species grouped under the same genus is supposed to have been less remote than the common ancestor of all the genera grouped under one family. The same reasoning is applied, *mutatis mutandis,* to the ancestry of families, orders and classes.

The logic of such inferences may be questioned, but there is no blinking the fact that, in practice, the genetic explanation of homology is assumed by scientists to be the only reasonable one possible. In fact, so strong is their confidence in the necessity of admitting a solution of this kind, that they do not hesitate to make it part and parcel of the definition of homology itself. For instance, on page 130 of Woodruff's "Foundations of Biology" (1922), we are informed that homology signifies "a fundamental similarity of structure based on descent from a common antecedent form." The Yale professor, however, has been outdone in this respect by Professor Calkins of Columbia, who discards the anatomical definition altogether

and substitutes, in lieu thereof, its evolutionary interpretation. "When organs have the same ancestry," he says, "that is, when they come from some common part of an ancestral type, they are said to be homologous." ("Biology," p. 165.) In short, F. A. Bather is using a consecrated formula culled from the modern biological creed when he says: "The old form of diagnosis was *per genus et differentiam.* The new form is *per proavum et modificationem.*" (*Science,* Sept. 17, 1920, p. 259.)

A moment's reflection, however, will make it clear that, in thus confounding the definition proper with its theoretical interpretation, the modern biologist is guilty of a logical atrocity. Homology, after all, is a simple anatomical fact, which can be quite adequately defined in terms of observation; nor is the definition improved in the least by having its factual elements diluted with explanatory theory. On the contrary, the definition is decidedly weakened by such redundancy. And as for those who insist on defining homology in terms of atavistic assumption instead of structural affinity, their procedure is tantamount to defining the clear by means of the obscure, an actual effect by means of a possible cause. Moreover, this attempt to load the dice in favor of Transformism by tampering with the definition of homology ends by defeating its own purpose. For, if homology is to serve as a legitimate argument for evolution, then obviously evolution must not be included in its definition; otherwise, the conclusion is anticipated in the premise, the question is begged, and the argument itself rendered a vicious circle.

Having formed a sufficiently clear conception of homology as a static fact, we are now in a position to consider the problem of its causality with reference to the solution proposed by evolutionists. Transmutation, they tell us, results from the interaction of a twofold process, namely, the conservative and similifying process called *inheritance,* and progressive and diversifying process known as *variation.* Inheritance by transmitting the ancestral likeness tends to bring about uniform-

ity. Variation by diverting old currents into new channels adjust organisms to new situations and brings about modification. Homology, therefore, is the effect of inheritance, while adaptedness or modification is the product of variation.

As here used, the term inheritance denotes something more than a mere recurrence of parental characters in the offspring. It signifies a process of genuine transmission from generation to generation. Strictly speaking, it is not the *characters*, such as coloration, shape, size, chemical composition, structural type, and functional specificity, that are "inherited," but rather the hereditary *factors* or chromosomal *genes*, which are actually transmitted, and of which the characters are but an external expression or manifestation. Hence, it is scarcely accurate to speak of "inherited," as distinguished from "acquired," characters. As a matter of fact, all somatic characters are joint products of the interaction of germinal and environmental factors. Consequently, the external character would be affected no less by a change in the environmental factors than by a change in the germinal factors. In a word, somatic characters are not the exclusive expression of the genetic factors, but are equally dependent upon environmental influence, and hence it is only to the extent that these characters are indicative of the specific constitution of the germ plasm that we may speak of them as "inherited," remembering that what is really transmitted to the offspring is a complex of genes or germinal factors, and not the characters themselves. The sense is, therefore, that "inherited" characters are manifestative of what is contained in the germ plasm, whereas "acquired" characters have no specific germinal basis, but are a resultant of the interaction between the somatic cells and the environment. In modern terminology, as we have seen, the aggregate of germinal factors transmitted in the process of reproduction is called the genotype, while the aggregate of somatic characters which manifest these germinal factors externally is spoken of as the phenotype. Only the genotype is transmitted, the phenotype

being the subsequent product of the interplay of genetic factors and environmental stimuli, dependent upon, and expressive of, both.

Variation, therefore, may be based upon a change in the germ plasm, or in the environment, or in both. If it rests exclusively upon an extraordinary change in the environmental conditions, the resulting modification is non-inheritable, and will disappear so soon as the exceptional environmental stimulus that evoked it is withdrawn. If, on the contrary, it is based upon a germinal change, it will manifest itself, even under ordinary, i.e. unchanged or uniform environmental influence. In this case, the modification is inheritable in the sense that it is the specific effect of a transmissible germinal factor, which has undergone alteration.

As we have seen in the foregoing chapter, there are three kinds of germinal change which result in "inheritable" modifications. The first is called factorial mutation, and is initiated by an alteration occurring in one or more of the chromosomal genes. The second is called chromosomal mutation, and is caused by duplication (or reduction) of the chromosomes. The third may be termed recombination, one type of which results from the crossover or exchange of genes between pairing chromosomes ("pseudomutation"), the other from random assortment in accordance with the Mendelian law of the independence of allelomorphic pairs. This so-called "random assortment of the chromosomes" is the result of the shuffling and free deals of the chromosomal cards of heredity which take place twice in the life-cycle of organisms: viz. first, in the process of gametic reduction (meiosis); second, in the chance meeting of variously-constituted sperms and eggs in fertilization. A mischance of the first of these "free deals" is bewailed in the following snatch from a parody belonging to the Woods Hole anthology.

"Oh chromosomes, my chromosomes,
How sad is my condition!
My grandsire's gift for writing well

Has gone to some lost polar cell
And so I write this doggerel,
I cannot do much better."

These kinds of variation, however, in so far as they fall within the range of actual observation, are confined within the limits of the organic species. Intra-specific variation, however, will not suffice. To account for the adaptive modifications superimposed upon underlying structural identity, Transformism is obliged to assume the possibility of trans-specific variation. Yet in none of the foregoing processes of variation do we find a valid factual basis for this assumption.

Factorial mutation, for instance, waiving its failure to produce naturally-viable forms, or to meet the physiological sterility test of a new species, admits of interpretation as a change of loss due to the "dropping out" of a gene from the germinal complex. Bateson's conception of evolution as a process consisting in the gradual loss of inhibitive genes, whose elimination releases suppressed potentialities, seems rather incredible. Many will be inclined to see in Castle's facetious epigram a *reductio ad absurdum* of Bateson's suggestion; for, according to the latter's view, as the Harvard professor remarks, we should have to regard *man* as *a simplified amœba*. Certainly, it seems nothing short of a contradiction to ascribe the progressive complication of the phenotype to a simplification of the genotype by loss.

On the other hand, not only is there no experimental evidence of a germinal change by positive acquisition, that is, by the addition of genes, but it is hard to conceive how such a change could come about. "At first," admits Bateson, "it may seem rank absurdity to suppose that the primordial form or forms of protoplasm could have contained complexity enough to produce the divers types of life." "But," he asks, "is it easier to imagine that these powers could have been conveyed by extrinsic addition? Of what nature could these additions be? Additions of material can not surely be in question. We are told that salts of iron in the soil may turn

a pink hydrangea blue. The iron cannot be passed on to the next generation. How can iron multiply itself? The power to assimilate iron is all that can be transmitted. A disease-producing organism like the pebrine of silkworms can in a very few cases be passed on through the germ cells. But it does not become part of the invaded host, and we can not conceive it taking part in the geometrically ordered processes of segregation. These illustrations may seem too gross; but what refinement will meet the requirements of the problem, that the thing introduced must be, as the living organism itself is, capable of multiplication and of subordinating itself in a definite system of segregation?" (*Heredity,* Smithson. Inst. Rpt. for 1915, p. 373.)

Nor can we agree with Prof. T. H. Morgan's contention that the foregoing difficulty of Bateson has been solved by the discovery of the chromosomal mutation. All unbalanced chromosomal mutants are subnormal in their viability and vitality, not to speak of their marked sterility. Haploidy represents a regressive, rather than a progressive, step. The triploid mutant is sterile. The tetraploid race of Daturas is inferior in fertility to the normal diploid plant. The origin of balanced tetraploidy from diploidy must be presumed, since it has never been observed. Moreover, tetraploidy represents only quantitative, and not qualitative, progress. The increased mass of the nucleus produces an enlargement of the cytoplasm, the result of which is giantism. This effect, however, is not specific; for giant and normal races possessing each the same number of chromosomes are known to exist in nature. Hence giantism may be due to other causes besides chromosomal duplication. The only effect of this doubling is a reinforcement and intensification of the former effect of the genetic factors, their specificity remaining unchanged. Double doses are substituted for single doses of the factors, but nothing really new is added. Morgan himself recognizes that this mere repetition of identical genes is insufficient, and that their multiplication must be qualitative as well as numerical, to answer

the specifications of a progressive step in evolution. Hence he suggests that the chromosomal mutation is subsequently supplemented by appropriate factorial mutation. Once this supposition is made, however, all the objections we have mentioned in connection with factorial mutation (*e.g* the subnormality of its products, its intra-specific nature, etc.) return to plague the speculator, and, in addition to these, he is confronted with the new difficulty of explaining how the redundance of duplicate genes can be removed and replaced by coördinate differentiation in their respective specificities. Now we have no factual evidence whatever of such a solidaric redifferentiation of the germinal factors, that would modify harmoniously the composition and rôle of each and every gene in the factorial complex. Nor is there any possibility whatever of accounting for this telic superregulation of the germinal regulators upon a purely mechanistic basis. How can the ultimate chemical determinants of heredity be thus redetermined? Consequently, although there is gametic incompatibility between diploid races and the tetraploid races, which are said to have arisen from the former, we are not, nevertheless, warranted, by what has been experimentally verified, in regarding tetraploid races as new species, or as progressive steps in the process of organic evolution.

To conclude, therefore, we have experimental verification of the efficacy of the similifying process said to have been at work in evolution, namely, inheritance The same, however, cannot be said of the correlative diversifying process of transspecific variation, which is said to have superficially modified old structures into new species. The latter process, accordingly, is but a pure postulate of science known to us only through the effect hypothetically assigned to it, namely, the adaptive modification.

The adaptation, however, of which there is question here is not to be confounded with the "acquired adaptation" of Lamarckian fame; for, unlike the latter, it is an inheritable modification rooted in the germ plasm. Adaptations of this

sort do, indeed, adjust the organism to its external environment, but they are innate and not acquired. Hence they are often spoken of as *preadaptations;* for they precede, in a sense, the organism's contact with the environing element to which they adjust it. They may possibly, it is true, have been acquired in the distant past, but they have now a specific germinal foundation, and no one was ever privileged to witness their initial production *de novo.* The whale, for example, though fundamentally a warm-blooded mammal, is superficially a fish, by reason of such a preadaptation to its marine environment. Preadaptation is of common occurrence, especially among parasites, symbiotes, commensals, and inquilines. Wasmann cites innumerable instances of beetles and flies so profoundly modified, in accommodation to their mode of life as guests in termite nests, that the systematist hesitates to classify them under any of the accepted orders of insects. Here the adaptive modification so disturbs the underlying homology as to make of these creatures taxonomical ambiguities. In the case of *Termitomyia,* he tells us, "the whole development of the individual has been so modified that it resembles that of a viviparous mammal rather than that of a fly." ("The Problem of Evolution," pp. 14, 15.)

Such modifications, however, amount to major, and not merely minor, differences. We are not dealing, therefore, with varietal distinctions here, but with specific, generic, and even ordinal differences. With reference to the phenomenon of adaptive modification,[1] three things, consequently, are worthy of note: (1) it has the semblance of being adventitious to the un-

[1] It may be remarked, in passing, that experimental genetics and mutation furnish no clue to the origin of adaptive characters. The Lamarckian idea alone gives promise in this direction. Orthogenesis leaves unsolved the mystery of preadaptation; yet only orthogenetic systems of evolution can be constructed on the basis of genetical facts. "Mutations and Mendelism," says Kellogg, "may explain the origin of new species in some measure, but they do not explain adaptation in the slightest degree." (*Atlantic Monthly,* April, 1924, pp. 488, 489.) We have seen in the previous chapter that they are impotent to explain in *any* measure the origin of new species.

derlying structural uniformity; (2) it is of such magnitude that it cannot be ascribed to variation within the species; (3) it has been appropriated by the hereditary process, in the sense that it is now an "inherited" character based on the transmission of specific germinal factors.

Now it is claimed that for the occurrence of this kind of modification in conjunction with homology only one rational explanation is possible, and that explanation is evolution. If this contention be a sound one, and Dorlodot, who claims certitude for the evolutionary solution, insists that it is such, then, in the name of sheer logical consistency, but one course lies open to us. We cannot stop at Wasmann's comma,[2] we must press on to the very end of the evolutionary sentence and sing with the choristers of Woods Hole:

"It's a long way from Amphioxus,
It's a long way to us;
It's a long way from Amphioxus,
To the meanest human cuss.
Good-bye fins and gill slits;
Welcome skin and hair.
It's a long, long way from Amphioxus,
But we came from there."

In this predicament it will not do, as we shall see presently, to adopt Mr. McCann's expedient of balancing anatomical differences against anatomical resemblances. To do so is to court certain and ignominious defeat. We must, therefore, examine the argument dispassionately. If it be solid, we must accept it and give it general application. If it be unsound, we must detect its flaws and expose them. Intellectual honesty allows us no alternative!

Moreover, in weighing the argument from organic homology we must not lose sight of the two important considerations previously stressed: (1) that the inference of common an-

[2] Rev. Erich Wasmann, S. J., accepts the evolutionary inference from homology as regards *plants* and *animals*. When it comes to *man*, however, he attempts to draw the line, and argues painstakingly against the assumption of a bestial origin of the human body.

cestry in the case of homologous forms is based, not upon this or that particular likeness, but upon an entire group of coördinated resemblances; (2) that the resemblances involved are not exterior similarities, but deep-seated structural uniformities perfectly compatible with diversities of a superficial and functional character. "Nothing," says Dr. W. W. Keen, "could be more unlike externally than the flipper of a whale and the arm of a man. Yet you find in the flipper the shoulderblade, humerus, radius, ulna, and a hand with the bones of four fingers masked in a mitten of skin." (*Science*, June 9, 1922, p. 605.)

In fact, the resemblances may, in certain instances, be so deeply submerged that they no longer appear in the adult organism at all and are only in evidence during a transitory phase of the embryological process. In such cases, the embryo or larva exhibits, at a particular stage, traces of a uniformity completely obliterated from the adult form. In short, though frequently presented as a distinct argument, embryological similarity, together with all else of value that can still be salvaged from the wreck of the Müller-Haeckel Law of Embryonic Recapitulation, is, at bottom, identical with the general evolutionary argument from homology. In the latter argument we are directed to look beneath the modified surface of the adult organism for surviving vestiges of the ancestral type. In the former, we are bidden to go deeper still, to the extent, that is, of descending into the very embryological process itself, in order to discover lingering traces of the ancestral likeness, which, though now utterly deleted from the transformed adult, are yet partially persistent in certain embryonic phases.

In sectioning a larval specimen of the fly-like termite-guest known as *Termitoxenia Heimi*, Father Wasmann came across a typical exemplification of this embryological atavism. In the adult insect, a pair of oar-like appendages replace the wings characteristic of the *Diptera* (flies). These appendages are organs of exudation, which elaborate a secretion whereof

the termites are very fond, and thereby render their possessors welcome guests in the nests of their hosts. The appendages, therefore, though now undoubtedly inherited characters, are the specific means by which these inquilines are adapted to their peculiar environment and mode of life among the termites. Moreover, the organs in question not only differ from wings functionally, but, in the adult, they bear no structural resemblance whatever to the wings of flies. Nevertheless, on examining his sections of the above-mentioned specimen, Wasmann found a developmental stage of brief duration during which wing veins appeared in the posterior branches of the embryonic appendages. Now, assuming that Wasmann's technique was faultless, his specimen normal, and his interpretation correct, it is rather difficult to avoid his conclusion that we have here, in this transitory larval phase, the last surviving vestige of ancestral wings now wholly obliterated from the adult type, that, consequently, this wingless termite guest is genetically related to the winged *Diptera*, and that we must see in the appendages aboriginal wings diverted from their primitive function and respecialized for the quite different purpose of serving as organs of exudation. (cf. "Modern Biology," p. 385.) Indeed, phenomena of this kind seem to admit of no other explanation than the atavistic one. It should be remembered, however, that Wasmann does not appear to have verified the observation in more than one specimen, and that a larger number of representative specimens would have to be accurately sectioned, strained, examined and interpreted, before any reliable conclusion could be drawn.[3]

Such, in its most general aspect, is the atavistic solution of the problem presented by the homology of types. In it,

[3] This transitory lymphatic, or tracheal venation appearing in the appendages at the stenogastric stage may not have the particular significance that Father Wasmann assigns. Such venation, even if vestigial and aborted, need not necessarily be a vestige of former *wing* venation. To demonstrate the validity of the atavistic interpretation, all other possible interpretations would have to be definitively excluded.

similarity and diversity are harmoniously reconciled, in the sense that they affect, respectively, different structural, or different developmental, levels. It is futile, therefore, to look for contradictions where they do not exist. In a word, the attempt to create opposition between a group of basic and correlated uniformities, on the one hand, and some particular external difference, on the other, is not only abortive, but absolutely irrelevant as well. The reason is obvious. Only when likeness is associated with unlikeness is it an argument for Transmutation. Likeness alone would demonstrate Immutability by indicating a process of pure inheritance as distinguished from the process of variation. Hence evolutionists do not merely concede the coëxistence of diversity with similarity, they gladly welcome this fact as vitally necessary to their contention.

Now it is precisely this point which Mr. McCann, like many other critics of evolution, fails utterly to apprehend. Consequently, his efforts to extricate the human foot from the toils of simian homology are entirely unavailing. To offset the force of the argument in question, it is by no means sufficient, as he apparently imagines, to point to the fact that, unlike the hallux of the ape, the great toe in man is non-opposable (cf. "God—or Gorilla," pp. 183, 184, and legends under cuts opposite pp. 184 and 318). The evolutionist will reply at once that the non-opposability of man's great toe is correlated with the specialization of the human foot for progression only, as distinguished from prehension; while, in the ape, whose foot has retained both the progressive and the prehensile function, the hallux is naturally opposable in adaptation to the animal's arboreal habits. He will then call attention to the undeniable fact that, despite these adaptational differences, the bones in the foot of a Troglodyte ape are, bone for bone, the counterparts of the bones in the human foot and not of those in the human hand. He will readily concede, that, so far as function and adaptedness go, this simian foot is a "hand," but he will not fail to point out that it is, at the

same time, a *heeled* hand equipped with a calcaneum, a talus, a navicular, a cuboid, and all other structural elements requisite to ally it to the human foot and distinguish it from the human hand. In fact, Mr. McCann's own photographs of the gorilla skeleton show these features quite distinctly, though he himself, for some reason or other, fails to speak of them. It is to be feared, however, that his adversaries may not take a charitable view of his reticence concerning the simian heel, but may be inclined to characterize his silence as "discreet," all the more so, that he himself has uncomplimentarily credited them with similar discretions in their treatment of unmanageable facts. In short, Mr. McCann's case against homology resembles the Homeric hero, Achilles, in being vulnerable at the "heel." At all events, the homology itself is an undeniable fact, and it is vain to tilt against this fact in the name of adaptational adjustments like "opposability" and "nonopposability." Since, therefore, our author has failed to prove that this feature is too radical to be classed as an adaptive modification, our only hope of exempting the human skeleton from the application of the argument in question is to show that argument itself is inconsequential.

Mr. McCann's predicament resembles that of the unlucky disputant, who having allowed a questionable major to pass unchallenged, strives to retrieve his mistake by picking flaws in a flawless minor. As Dwight has well said of the human body, "it differs in degree only from that of apes and monkeys," and "if we compare the individual bones with those of apes we cannot fail to see the correspondence." ("Thoughts of a Catholic Anatomist," p. 149.) In short, there exists no valid anatomical consideration whatever to justify us in subtracting the human frame from the extension of the general conclusion deduced from homology. Whosoever, therefore, sees in the homology of organic forms conclusive evidence of descent from a common ancestor, cannot, without grave inconsistency, reject the doctrine of the bestial origin of man. He may still, it is true, exclude the

human mind or soul from the evolutionary account of origins, but, if homology is, in any sense, a sound argument for common descent, the evolutionary origin of the human body is a foregone conclusion, and none of the anatomical "differences in degree" will avail to spare us the humiliation of sharing with the ape a common family-tree. It remains for us, then, to reëxamine the argument critically for the purpose of determining as precisely as possible its adequacy as a genuine demonstration.

To begin with, it must be frankly acknowledged that here the theory of transformism is, to all appearances, upon very strong ground. Its first strategic advantage over the theory of immutability consists in the fact that, unlike the latter, its attitude towards the problem is positive and not negative. When challenged to explain the structural uniformities observed in organic Nature, the theory of immutability is mute, because it knows of no second causes or natural agencies adequate to account for the facts. It can only account for homology by ascribing the phenomenon exclusively to the unity of the First Cause, and, while this may, of course, be the true and sole explanation, to assume it is tantamount to removing the problem altogether from the province of natural science. Hence it is not to be wondered at that scientists prefer the theory of transformism, which by assigning intermediate causes between the First Cause and the ultimate effects, vindicates the problem of organic origins for natural science, in assuming the phenomena to be proximately explicable by means of natural agencies. Asked whether he believes that God created the now exclusively arboreal Sloth (*Bradypus*) in a tree, the most uncompromising defender of fixism will hesitate to reply in the affirmative. Yet, in this case, what is nowadays, at least, an inherited preadaptation, dedicates the animal irrevocably to tree-life, and makes its survival upon the ground impossible.

Analogous preadaptations occur in conjunction with the phenomena of parasitism, symbiosis and commensalism, all of

which offer instances of otherwise disparate and unrelated organisms that are inseparably bound together, in some apparently capricious and fortuitous respect, by a preadaptation of the one to the other. Parasites, guests, or symbiotes, as the case may be, they are now indissolubly wedded to some determinate species of host by reason of an appropriate and congenital adjustment. For all that, however, the association seems to be a contingent one, and it appears incredible that the associates were always united, as at present, by bonds of reciprocal advantage, mutual dependence, or one-sided exploitation. Yet the basis of the relationship is in each case a now inherited adaptation, which, if it does not represent the primitive condition of the race, must at some time have been acquired. For phenomena such as these, orthogenesis, which makes an organ the exclusive product of internal factors, conceiving it as a preformed mechanism that subsequently selects a suitable function, has no satisfactory explanation. Lamarckism, which asserts the priority of function and makes the environment mold the organ, is equally inacceptable, in that it flouts experiences and ignores the now demonstrated existence of internal hereditary factors. But, if between these two extremes some evolutionary *via media* could be found, one must confess that it would offer the only conceivable "natural explanation" of preadaptation.[4] All this, of course, is pure speculation, but it serves to show that here, at any rate, the theory of Transformism occupies a position from which it cannot easily be dislodged.

But, besides the advantage of being able to offer a "natural explanation" of the association of homology with adaptation,

[4] Vernon Kellogg has expressed this same view in a recent article, though he frankly admits that it is an as yet unrealized desideratum. "Altogether," he says, "it must be fairly confessed that evolutionists would welcome the discovery of the actual possibility and the mechanism of transferring into the heredity of organisms such adaptive changes as can be acquired by individuals in their lifetime. It would give them an explanation of evolution, especially of adaptation, much more satisfactory than any other explanation at present claiming the acceptance of biologists." (*Atlantic Monthly*, April, 1924, p. 488.)

Transformism enjoys the additional advantage of being able to make the imagination its partisan by means of a visual appeal. Such an appeal is always more potent than that of pure logic stripped of sensuous imagery. When it comes to vividness and persuasiveness, the syllogism is no match for the object-lesson. Retinal impressions have a hypnotic influence that is not readily exorcised by considerations of an abstract order—"*Segnius irritant demissa per aurem, Quam quae sunt oculis subjecta fidelibus,*" says Horace, in the "Ars Poetica." Philosophers may distinguish between the magnetic appeal of a graphic presentation and the logical cogency of the doctrine so presented, but there is no denying that, in practice, imagination is often mistaken for reason and persuasion for conviction. Be that as it may, the ordinary method of bringing home to the student the evolutionary significance of homology is certainly one that utilizes to the full all the advantages of visual presentation. Given a class of impressionable premedics and coeds; given an instructor's table with skeletons of a man, a flamingo, an ape and a dog hierarchically arranged thereon; given an instructor sufficiently versed in comparative osteology to direct attention to the points in which the skeletons concur: and there can be no doubt whatever as to the psychological result. The student forms spontaneously the notion of a common vertebrate type, and the instructor assures him that this "general type" is not, as it would be with respect to other subject matter, a mere universal idea with no formal existence outside the mind, but rather a venerable family likeness, posed for originally by a single pair of ancestors (or could it possibly have been, by one self-fertilizing hermaphrodite?) and recopied from generation to generation, with certain variations on the original theme, by the hand of an artist called Heredity. This explanation may be true, but logically consequential it is not. However, if the dialectic is poor, the pedagogy is beyond reproach, and the solution proposed has in its favor the fact that it accords well with the student's limited experience. He is aware of the truism that children re-

semble their parents. Why look for more recondite explanations when one so obvious is at hand? The atavistic theory gratifies his instinct for simplification, and, if he be of a mechanistic turn of mind, the alternative conception of creationism is quite intolerable. Nevertheless, it goes without saying that the "inference" of common descent from the data of homology is not a ratiocination at all, it is only a simple apprehension, a mere abstraction of similarity from similars—*"Unde quaecumque inveniuntur convenire in aliqua intentione intellecta,"* says Aquinas, *"voluerunt quod convenirent in una re."* (*In lib. II sent., dist.* 17, *q. I, a.* 1) Philosophy tells us that the oneness of the universal is conceptual and not at all extramental or real, but the transformist insists that the universal types of Zoölogy and Botany are endowed with real as well as logical unity, that real unity being the unity of the common ancestor.

Certainly, from the standpoint of practical effectiveness, the evolutionary argument leaves little to be desired. The presentation is graphic and the solution simple. But for the critic, to whom logical sequence is of more moment than psychological appeal, this is not enough. To withstand the gnawing tooth of Time and the remorseless probing of corrosive human reason, theories must rest on something sounder than a mirage of visual imagery!

> Tell me where is fancy bred,
> Or in the heart or in the head?
> How begot, how nourished?
> Reply, reply.
> It is engendered in the eyes,
> With gazing fed; and fancy dies
> In the cradle where it lies.

But is it fair thus to characterize the "common ancestors" of Transformism as figments which, like all other abstractions, have no extramental existence apart from the concrete objects whence they were conceived? To be sure, their claim to be real entities cannot be substantiated by direct observation or ex-

periment, and so a factual proof is out of the question. Man, the late-comer, not having been present at the birth of organic forms, can give no reliable testimony regarding their parentage. In like manner, no *a priori* proof from the process of inheritance is available, because heredity, as revealed to us by the experimental science of Genetics, can account for specific resemblances only, and cannot be invoked, at present, as an empirically tested explanation for generic, ordinal, or phyletic resemblances. It has still to be demonstrated experimentally that the hereditary process is transcendental to limits imposed by specific differentiation. There remains, however, the *a posteriori* argument, which interprets homology and adaptation as univocal effects ascribable to no other agency than the dual process of inheritance and variation. What are we to think of this argument? Does it generate certainty in the mind, or merely probability?

A moment's reflection will bring to light the preliminary flaw of incomplete enumeration of possibilities. To suppose that inheritance alone can account for structural resemblance is an unwarranted assumption. Without a doubt, there are other similifying influences at work in Nature besides inheritance. True, inheritance is one possible explanation of the similarity of organisms, but it is not the *only* one. Even among the chemical elements of inorganic nature we find analogous uniformities or "family traits," which, in the absence of any reproductive process whatever, we cannot possibly attribute to inheritance. Mendeléeff's discovery of the periodicity of the elements, arranged in the order of their atomic weights, is well-known. At each interval of an octave, a succession of chemical types, similar to those of the preceding octave, recur. Hence elements appearing in the same vertical column of the Periodic Table have many properties in common and exhibit what may be called a family resemblance. Now, we have in the process of atomic disintegration, as observed in radioactive elements and interpreted by the electronic theory of atomic structure, a reasonably satisfactory basis

upon which to account for the existence of these inorganic uniformities. Here analogous chemical constitution, produced in accordance with a general law, results in uniformity that implies a similar, rather than an identical, cause. The hypothesis of parallelistic derivation from similar independent origins accounts quite as well for the observed uniformities as does the hypothesis of divergent derivation from a single common origin. Why, then, should we lean so heavily on the already overtaxed principle of inheritance, when parallelism is as much a possibility in the organic world as it is an actuality in the inorganic world°

As to the contrast here drawn between inheritance and other similifying factors, it is hardly necessary to remark that we are speaking of inheritance as defined in terms of Mendelian experiment and cytological observation. In the so-called chemical theory of inheritance, the distinction would be meaningless and the contrast would not exist. Ehrlich's disciple, Adami, sets aside all self-propagating germinal determinants, like the chromomeres, in favor of a hypothetical "biophoric molecule," which is to be conceived as a benzine-like ring bristling with sidechains. Around this determining core the future organism is built up in definite specificity, as an arch is constructed about a template. Adami has merely applied Paul Ehrlich's ideas concerning metabolism and immunity to the question of heredity, commandeering for this purpose the latter's entire toolkit of receptors, haptophores, amboceptors, etc., as though this grotesque paraphernalia of crude and clumsy mechanical symbols (which look for all the world like the wrenches of a machinist, or the lifters used by the cook to remove hot lids from the kitchen range) could throw any valuable light whatsoever on the exceedingly complex, and manifestly vital, phenomenon of inheritance. It does not even deserve to be called a chemical theory, for, as Starling correctly remarks concerning Ehrlich's conception, "though chemical in form," it is not so in reality, because "it does not explain the phenomenon by reference to the known laws of chemistry."

(Cf. *Physiology*, ed. of 1920, p. 1084.) In a word, the theory of heredity, which seeks to strip inheritance of its uniqueness as a vital process by identifying it with the more general physicochemical processes occurring in the organism, is a groundless speculation, that, far from explaining, flouts the very observational data which it pretends to elucidate. *Kurz und gut!* to requite the mechanist, Schäfer, with his own Danielesque phrase, here, as elsewhere, the mechanists have succeeded in extracting from the facts, not what the facts themselves proclaim, but what preëxisted in their own highly-cultured imaginations so well-stocked with cogs, cranks, ball bearings, and other æsthetic imagery emanating from polytechnic schools and factories.

But in arguing from the existence of parallelism in the inorganic world to its possibility in the organic world, we are less liable to displease the mechanists than those other extremists, the neo-vitalists, who will be prone to deny all parity between living, and inanimate, matter. Fortunately, we are in a position to appease the scruples of the latter by referring to the facts of *convergence* as universally accepted evidence that the phenomenon of parallelism occurs in animate, no less than inanimate, nature. Admitting, therefore, that the laws of organic morphology are of a higher order than those which regulate atomic, molecular, and multimolecular structure, these facts attest, nevertheless, that parallelisms arise in organisms of separate ancestry which are due, not to heredity, but to the uniform action of universal morphogenetic forces. Hence general laws can be invoked to account for organic uniformities with the same right that they are invoked to account for resemblances existing between the various members of a chemical "family" like the Halogens. And why should this not be so? Organisms have much in common that transcends any possible scheme of evolution and that cannot be brought into alignment with the position arbitrarily assigned them in the evolutionary family-tree. They all originate as single cells. Their common means of growth

and reproduction is mitotic cell division. This leads to the production of a *somatella,* among the protista, and of a *soma* differentiated by histogenesis into two or three primary tissues, among the metista. All these fundamental processes are strikingly uniform throughout the entire plant and animal world. In these universal properties of living matter, therefore, we have a common basis for general structural and organizational laws, which, though irreducible to the "common ancestors" of Transformism, is quite adequate to account for both the homologies and analogies of living matter. Accept this basis of general laws regulating the development of living matter, and there is no difficulty in seeing why the problems posed by exposure to analogous environmental conditions are solved in parallel fashion by organisms, irrespective of whether they are nearly, or distantly, related in the sense of morphology. Transformism, on the other hand, can only account for homology at the expense of convergence, and for convergence at the expense of homology. So far as a common ancestral basis is concerned, the two kinds of resemblance are, from the very nature of the case, irreducible phenomena.

It is only, in fact, by surrendering the principle that similarity entails community of origin, and by falling back on the suggested common basis of general laws, that Transformism makes room in its system for the troublesome facts of convergence. "It might be reiterated in passing," says Dwight, "that this 'convergence' business is a very ticklish one. We have been taught almost word for word that resemblance implies relationship, or almost predicates it; but according to this doctrine it has nothing to do with it whatever." ("Thoughts of a Cath. Anat.," p. 190.) And in a subsequent chapter he says: "No very deep knowledge of comparative anatomy is needed for us to know that very similar adaptations for particular purposes are found in very diverse animals. The curious low grade mammal, the *Ornithorhynchus,* with a hairy coat and the bill of a duck, is a familiar instance. We

all know that the whales have the general form of the fish, although they are mammals, and going more into details we know that the whale's flipper is on the same general plan as that of the ancient saurians. . . . The origin of the eye, according to evolutionary doctrines, has been a very difficult problem, which gets worse rather than better the more you do for it. Even if we could persuade ourselves that certain cells blundered along by the lucky mating of individuals in whom they were a bit better developed than in the others till they came to form a most complicated organ of sight, it would be a sufficient tax on our credulity to believe that this could come off successfully in some extraordinary lucky species; but that it should have turned out so well with all kinds of vertebrates is really too much to ask us to swallow. But this is not all: eyes are very widely spread among different classes of invertebrates. More wonderful still, the eyes of certain molluscs and crustacea are on stalks, and this is found also in various and very different families of fishes. How did this happen? Was it by way of descent from the molluscs or the crustacea? If not, how could chance have brought about such a similar result in diverse forms?" (*Op. cit.*, pp. 233-236.)

It may be objected that the resemblances of convergence are superficial analogies, not to be confounded with fundamental homologies. This contention may be disputed; for, as we shall see in the next chapter, there are cases where the convergence is admittedly radical, and not merely superficial. The distinction, moreover, between shallow and basic characters is somewhat arbitrary, and its validity is often questionable. When the skeletal homology that relates the amphibia to the mammals, for instance, is traced to the root of the vertebrate family tree, we find it all but disappearing in a primitive Amphioxus-like chordate, whose so-called skeleton contains no trace of bone or cartilage. Hence, if we go back far enough, the homologies of to-day become the convergences of a geological yesterday, and we find the vertebrate

type of skeleton arising independently in reptiles, mammals, amphibia, and fishes.

Again, there are times when convergent analogies appear to be more representative of the common racial heritage than the underlying structure itself, tempting the evolutionist to fly in the face of the orthodox interpretation, which rigidly rules out analogy in favor of homology, and refuses to accept the eloquent testimony of a remarkable resemblance merely because of a slight technical discrepancy in the structural substrate. A large pinching claw, or chela, for example, occurs in two organisms belonging to the phylum of the arthropods, namely, the lobster and the African scorpion. Both chelæ are practically identical in structure, but, unfortunately, the chela of the lobster arises from a different appendage than that from which the scorpion's chela emerges. If they arose from corresponding appendages, they would be pronounced "homologous organs" and acclaimed, without hesitation, as strong evidence in favor of the common origin of all the arthropods. In proof of this, we call attention to the importance attached to the adaptations affecting homologous bones in fossil "horses." As it is, however, the two chelæ are analogous, and not homologous, organs. Hence, technically speaking, the two chelæ are utterly unrelated structures. To the eye of common sense, however, the likeness appears to be far more important than the difference, and the average person will be inclined to view the resemblance as evidence of a communuity of type. In fact, the tendency to discard superficial, and to retain only fundamental, uniformities, is dangerous to the theory of Transformism. When we confine our attention to what is really basic, we find that the resemblances become so generalized and widespread that specific conclusions as to descent become impossible, and we lose all sense of direction in a clueless labyrinth of innumerable, yet mutually contradictory, possibilities.

Finally, it may be noted in passing that, though it is

customary with evolutionists to regard homologous characters as the tenaciously persistent heritage of primeval days, and to look upon adaptational characters as adventitious and accessory to the aforesaid primitive heritage, the supposedly older and more fundamental characters fail to give, by the manifestation of greater fixity, any empirical evidence whatever of their being more deeply or firmly rooted in the hereditary process than the presumably newer adaptational characters. We have, therefore, no experimental warrant for appropriating homologous, rather than adaptational, characters to the process of inheritance. "It is sometimes asserted," says Goodrich, "that old-established characters are inherited, and that newly begotten ones are not, or are less constant, in their reappearance. This statement will not bear critical examination. For, on the one hand, it has been conclusively shown by experimental breeding that the newest characters may be inherited as constantly as the most ancient. . . . While, on the other hand, few characters in plants can be older than the green color due to chlorophyll, yet it is sufficient to cut off the light from a germinating seed for the greenness to fail to appear. Again, ever since Devonian times vertebrates have inherited paired eyes; yet, as Professor Stockard has shown, if a little magnesium chloride is added to the sea water in which the eggs of the fish *Fundulus* are developing, they will give rise to embryos with one median cyclopean eye! Nor is the suggestion any happier that the, so to speak, more deep-seated and fundamental characters are more constantly inherited than the trivial or superficial. A glance at the organisms around us, or the slightest experimental trial, soon convinces us that the apparently least important character may reappear as constantly as the most fundamental. But while an organism may live without some trivial character, it can rarely do so when a fundamental character is absent, hence such incomplete individuals are seldom met in Nature." (*Science*, Dec. 2, 1921, p. 530.)

But, whether it be upon, or beneath, the surface, similitude of *any kind* suffices to establish our contention that inheritance is not the only similifying influence present in organisms, and that resemblance is perfectly compatible with independence of ancestry. We have, therefore, an alternative for inheritance in the explanation of organic uniformities, and by the admission of this alternative, which, for the rest, is factually attested by the universally acknowledged phenomena of convergence, the inference of common descent from structural resemblance is shorn of the last remnant of its demonstrative force, as an *a posteriori* argument.

But a still more serious objection to the evolutionary interpretation of homology and preadaptation arises from its intrinsic *incoherency*. Evolution, as previously stated, is assumed to be the resultant of a twofold process, namely, *inheritance* and *variation*. The first is a conservative and similifying process, which transmits. The second is a progressive and diversifying process, which diverts. To the former process are due the uniformities of homology, to the latter the deviations of adaptation. Upon the admission of evolutionists themselves, however, neither of these processes behaves in a manner consistent with its general nature, and both of them are flagrantly unfaithful to the principal rôles assigned to them. Nowadays the hereditary process transmits *adaptational*, as well as *homologous*, characters. If, then, adaptational characters are more recent than homologous characters, there must have been a time when inheritance ceased to *similify* and become a *diversifying* process by transmitting what it did not receive from the previous generation. There were times when, not content with simply reiterating the past, it began to divert former tendencies into novel channels. In other words, inheritance becomes dualized into a paradoxical process, which both perpetuates the old and appropriates the new. The same inconsistency is manifest in the process of variation, which capriciously produces *convergent*, no less than *divergent*, adaptations. In two fundamentally identical

structures, like the wing of a bird and the foreleg of a cat, variation is said to have produced diverse adaptations. In two fundamentally diverse structures, like the head of an octopus and the head of a frog, variation is said to have produced an identical adaptation, namely, the vetebrate type of eye. It appears, therefore, that the essentially diversifying process of variation can become, on occasion, a simplifying process, which, instead of solving environmental problems in an original manner, prefers to employ uniform and standardized solutions, and to cling to its old stereotyped methods. Inheritance similifies and diversifies, variation converges and diverges. It is futile to attempt to reduce either of these protean processes to a condition that even approximates consistency. The evolutionist blows hot and cold with the same breath. Verily, his god is Proteus, or the double-headed Janus!

Summa summarum: The evolutionary argument from homology is defective in three important respects: (1) in its lack of experimental confirmation; (2) in its incomplete enumeration of the disjunctive possibilities; (3) in its inability to construct a scheme of transmutation that synthesizes inheritance and variation in a logically coherent, and factually substantiated formula. The first two defects are not necessarily fatal to the argument as such. Though they destroy its pretensions to conclusiveness, they do not preclude the fulfilment of the moderate claim made in its behalf by Prof. T. H. Morgan, who says: "In this sense (*i.e.*, as previously stated) the argument from comparative anatomy, while not a demonstration, carries with it, I think, a high degree of probability." ("A Critique of the Theory of Evolution," p. 14.) The third defect is more serious. The apparently irreducible antagonism which the evolutionary assumption introduces between inheritance and variation has been sensed even by the adherents of transformism themselves, and they have searched in vain for a formula, which, without sacrificing the facts, would bring into concord the respective rôles of these discordant factors. "It follows," says Osborn, "as an unprejudiced

conclusion from our present evidence that upon Weismann's principle we can explain inheritance but not evolution, while with Lamarck's principle and Darwin's selection principle we can explain evolution, but not, at present, inheritance. Disprove Lamarck's principle and we must assume that there is some third factor in evolution of which we are ignorant." (*Popular Science Monthly,* Jan., 1905.) The point is well taken, and unless, as Osborn suggests, there is a *tertium quid* by means of which the discord can be resolved into ultimate harmony, we see no way of liberating the theory of Transmutation from this embarrassing dilemma.

CHAPTER III

FOSSIL PEDIGREES

"By dint of such great efforts we succeeded only in piecing together genial romances more or less historical."—B. Grassi, Prof. of Comparative Anatomy, Univ. of Rome, "La vita" (1906), p. 227.

§ 1. **The Argument in the Abstract**

The palæontological argument for evolution is based upon the observed gradual approximation in type of the earlier forms of life, as represented by the fossils still preserved in successive geological strata, to the later forms of life, as represented by the contemporary species constituting our present flora and fauna. Here the observed distribution in time supplements and confirms the argument drawn from mere structural affinity. Here we are no longer dealing with the spatial gradation of contemporary forms, arranged on a basis of greater or lesser similarity (the gradation whence the zoölogist derives his argument for evolution), but with a temporal gradation, which is simultaneously a morphological series and an historical record. The lower sedimentary rocks contain specimens of organic life very unlike modern species, but, the higher we ascend in the geological strata, the more closely do the fossil forms resemble our present organisms. In fact, the closeness of resemblance is directly proportional to the proximity in time, and this seems to create a presumption that the later forms of life are the modified descendants of the earlier forms. Considered in the abstract, at least, such an argument is obviously more formidable than the purely anatomical argument based on the degrees of structural affinity observable in contemporary forms. It ought, therefore, to

be extremely persuasive, provided, of course, it proceeds in rigorous accord with indubitably established facts and rules out relentlessly the alloy of uncritical assumptions.

Here, likewise, we find the theory of transformism asserting its superiority over the theory of immutability, on the ground that evolutionism can furnish a natural explanation for the gradational distribution of fossil types in the geological strata, whereas the theory of permanence resorts, it is said, to a supernaturalism of reiterated "new creations" alternating with "catastrophic exterminations." Now, if this claim is valid, and it can be shown conclusively that fixism is inevitably committed to a postulate of superfluously numerous "creations," then the latter theory is shorn of all right to consideration by Occam's Razor: *Entia non sunt multiplicanda sine ratione.* It is rather difficult to conceive of the Creator as continually blotting out, and rewriting, the history of creation, as ruthlessly exterminating the organisms of one age, only to repopulate the earth subsequently with species differing but little from their extinct predecessors—*ad quid perditio haec?* Such procedure hardly comports with the continuity, regularity and irrevisable perfection to be expected in the works of that Divine Wisdom, which "reacheth . . . from end to end mightily and disposeth all things sweetly" (*Wisdom,* viii; 1), which "ordereth all things in measure, and number and weight." (*Wis.* xi; 21.)

Following the lead of other evolutionists, Wasmann has striven to saddle fixism with the fatuity of periodic catastrophism and "creation on the installment plan." But even Cuvier, who is credited with having originated the theory of catastrophism, did not go to the absurd extreme of hypothecating reiterated creations, but sought to explain the repopulation of the earth after each catastrophe by means of migrations from distant regions unaffected by the catastrophe. Historically, too, fixism has had its uniformitarian, as well as its catastrophic, versions. In fact, Huxley classifies both uniformitarianism and catastrophism as fixistic systems, when

he says: "I find three more or less contradictory systems of geologic thought . . . standing side by side in Britain. I shall call one of them Catastrophism, another Uniformitarianism, the third Evolutionism." ("Lay Sermons," p. 229.) Obviously, then, fixism is separable from the hypothesis of repeated catastrophes alternating with repeated "creations." Stated in proper terms, it is at one with evolutionism in rejecting as undemonstrated and improbable the postulate of reiterated cataclysms. It freely acknowledges that, in the absence of positive evidence of their occurrence, the presumption is against extraordinary events, like wholesale catastrophes. It sanctions the uniformitarian tenet that ordinary cosmic processes are to be preferred to exceptional ones as a basis of geological explanation, and it repudiates as unscientific any recourse to the unusual or the miraculous in accounting for natural phenomena. Its sole point of disagreement with evolutionism is its refusal to admit organic changes of *specific* magnitude. It does, however, admit germinal changes of *varietal* magnitude. It also recognizes that the external characters of the phenotype are the joint product of germinal factors and environmental stimuli, and admits, in consequence, the possibility of purely *somatic changes* of considerable profundity being induced by widespread and persistent alterations in environmental conditions. Like Darwin, the uniformitarian fixist ascribes the origination of organic life to a single vivifying act on the part of the Creator, an act, however, that was *formative* rather than *creative,* because the primal forms of life, whether few or many, were all evolved through Divine influence from preëxistent inorganic matter. Unlike Darwin, he ascribes the continuation of organic life to generative processes that were univocal (*generationes univocae*), and not gradually-equivocal (*generationes paulatim aequivocae*). In the next chapter, we shall see that, in attributing the initial formation of species to a Divine act, neither Darwin nor the creationists exposed themselves to the charge of explaining the "natural" by means of the "miraculous." And, as for

the process by which living forms were continued upon earth, the univocal reproductive process upheld by fixism is more manifestly a natural process than the gradually-equivocal generation of variable inheritance hypothecated by the theory of transmutation. The sole matter of dispute between the two views is whether the life-cycles of organisms are circles or spirals.

But all this, it will be said, is purely negative. Merely to refrain from any recourse to the extraordinary or the supernatural is by no means sufficient. "Natural explanations" must be explanatory as well as natural. Unless there be a simplification, a reduction of plurality to unity, a resolution of many particular problems into a common general problem, we have no explanation worthy of the name. Granting, therefore, that uniformitarian fixism does not recur to the anomalous or the miraculous, it still lies open to the charge of failing in its function as an explanation, because it multiplies origins in both space and time. Transformism, on the contrary, is said to elucidate matters, inasmuch as it unifies origins spatially and temporally.

That transformism successfully plausibleizes a unification of origins in space, is true only in a limited and relative sense. The most that can be said for the assumption, that resemblances rest on the principle of common inheritance, is that it permits of a numerical reduction of origins, but this numerical reduction will, by an intrinsic necessity, always fall short of absolute unification. The monophyletic derivation of all organic forms from one primordial cell or protoblast is a fantastic dream, for which, from the very nature of things, natural science does not, and can not, furnish even the semblance of an objective basis. The ground is cut from under our feet, the moment we attempt to extend the principle of descent outside the limits of an organic phylum. The sole basis of inference is a group of uniformities, and, unless these uniformities predominate over the diversities, there can be no rational application of the principle of transformism. Hence,

the hypothesis, that organisms are consanguineous notwithstanding their differences, loses all value as a solution at the point where resemblances are outweighed by diversities. The transmutation assumed to have taken place must be never so complete as to have obliterated all recognizable vestiges of the common ancestral type. "Whenever," says Driesch, "the theory that, in spite of their diversities, the organisms are related by blood, is to be really useful for explanation, it must necessarily be assumed in every case that the steps of change, which have led the specific form A to become the specific form B, have been such as only to change in part that original form A. That is to say: the similarities between A and B must never be overshadowed by their diversities." ("Science and Philosophy of the Organism," v. I, p. 254.) When, therefore, the reverse is true and diversities are prevalent over uniformities, we are left without clue or compass in the midst of a labyrinth of innumerable possibilities. Such are the limits imposed by the very nature of the evidence itself, and the scientists, who transgress these limits, by attempting to correlate the primary phyla, are on a par with those unconvincible geniuses, who continually besiege the Patent Office with schemes ever new and weird for realizing the chimera of "perpetual motion."

Thus scientific transformism is unable to simplify the problem beyond a certain irreducible plurality of forms, lesser only in degree than the plurality postulated by fixism. This being the case, the attempts of Wasmann and Dorlodot to prune the works of Creation with Occam's Razor are not only presumptuous, but precarious as well. *Qui nimis probat, nihil probat!* If it be unworthy of God to multiply organic origins in space, then monophyletic descent is the only possible alternative, and polyphyletic transformism falls under the same condemnation as fixism. Yet the polyphyletic theory of descent is that to which both Wasmann and Dorlodot subscribe, as it is, likewise, the only kind of transformism which science can ever hope to plausibleize. Besides, too close a

shave with Occam's Razor would eliminate creation altogether, since all theologians cheerfully admit that it was the result of a free and unnecessary act on the part of God. When we apply our *rationes convenientiae* to the Divine operations, we must not make the mistake of applying them to the Divine action itself instead of the created effects of that action. We may be competent to discern disorder and irregularity in finite things, but we are wholly incompetent to prescribe rules for Divine conduct. To say that God is constrained by His infinite Wisdom to indirect, rather than direct, production, or that He must evolve a variety of forms out of living, rather than non-living, matter, is to be guilty of ridiculous anthropomorphism. There is no *a priori* reason, founded upon the Divine attributes, which restricts God's creative action to the production of this, or that, number of primordial organisms, or which obliges him to endow primitive organisms with the power of transmutation.

But the fact that these *rationes convenientiae* fail to establish the *a priori* necessity of a unification of organic origins in space, does not imply that they are without value in suggesting the unification of organic origins in time. Order and regularity are not excluded by spatial multiplicity, but they may easily be excluded by the incongruities of an irregular succession of events. Indeterminism and chance are, indeed, inseparable from the course of Nature. There is in matter an unlimited potentiality, incommensurate with the limited efficacy of natural agencies. Hence it evades the absolute control of all finite factors and forces. But the anomalies and irregularities, which are contingent upon the limitation or frustration of second causes unable to impose an iron necessity upon evasive matter, are not referable to the First Cause, but rather to the finite efficacy of second causes. Such anomalies in natural processes, consequently, are not inconsistent with infinite wisdom and power on the part of the Creator. If, on the contrary, the anomaly occurs, not in the form of an accidental frustration of a natural agency, but in the form of an intrusive

"new creation," the irregularity in question would then be referable to the Creator Himself, and such derogations of order are inadmissible, except as manifestations of the supernatural. In fact, the abrupt and capricious insertion of a "new creation" into an order already constituted, say, for instance, the sudden introduction of Angiosperms in the Comanchian period, or of mammals in the Tertiary, would be out of harmony with both reason and revelation. Unless there is a positive reason for supposing the contrary, we must presume that, subsequent to the primordial constitution of things, the Divine influence upon the world has been concurrent rather than revolutionizing. Hence a theory of origins, compatible with the simultaneous "creation" of primal organisms, is decidedly preferable to a theory, which involves successive "creations" at random. That transformism dispenses with the need of assuming a succession of "creative" acts, is perfectly obvious, and, unless fixism can emulate its rival system in this respect, it cannot expect to receive serious attention.

But once fixism assumes the simultaneousness of organic origins, it encounters, in the absence of modern organic types from ancient geological strata, a new and formidable difficulty. Cuvier's theory of numerous catastrophes followed by wholesale migrations of the forms, which had escaped extinction, is tantamount to an appeal to the extraordinary and the improbable for purposes of explanation, and this, as we have seen, is an expedient, which natural science is justified in refusing to sanction. Nor does the appeal to the incompleteness of the geological record offer a more satisfactory solution. It is tax enough, as we shall see, upon our credulity, when the transformist seeks to account thereby for the absence of intermediate types, but to account in this fashion for the absence of palæozoic Angiosperms and mammals is asking us to believe the all-but-incredible. It would not, therefore, be advisable for the fixist to appropriate the line of defense suggested for him by Bateson—"It has been asked how do you

know for instance that there were no mammals in Palæozoic times? May there not have been mammals somewhere on the earth though no vestige of them has come down to us? We may feel confident there were no mammals then, but are we sure? In very ancient rocks most of the great orders of animals are represented. The absence of the others might by no great stress of imagination be ascribed to accidental circumstances." But the sudden rise of the Angiosperms in the early part of the Mesozoic era is an instance of *de novo* origin that is not so easily explained away. Hence Bateson continues: "Happily, however, there is one example of which we can be sure. There were no Angiosperms—that is to say 'higher plants' with protected seeds—in the carboniferous epoch. Of that age we have abundant remains of a world-wide and rich flora. The Angiosperms are cosmopolitan. By their means of dispersal they must immediately have become so. Their remains are very readily preserved. If they had been in existence on the earth in carboniferous times they must have been present with the carboniferous plants, and must have been preserved with them. Hence we may be sure that they did appear on earth since those times. We are not certain, using certain in the strict sense, that Angiosperms are the lineal descendants of the carboniferous plants, but it is much easier to believe that they are than that they are not." (*Science*, Jan. 20, 1922, p. 58.)

It would thus appear, that not all the organic types of either the plant, or the animal, kingdom are of equal antiquity, and that the belated rise of unprecedented forms has the status of an approximate certainty, wherewith every theory of origins must inevitably reckon. How, then, is the fixist to reconcile this successive appearance of organisms with the simultaneous "creation" advocated by St. Augustine and St. Thomas of Aquin? Unless there be some other gradual process besides transmutation, to bridge the interval between the creative fiat and the eventual appearance of modern types, there seems to be no escape from the dilemma.

This brings us to St. Augustine's theory of the evolution of organic life from inorganic matter, which Dorlodot sophistically construes as supporting the theory of descent. According to St. Augustine, for whose view the Angelic Doctor expressed a deliberate preference, the creation of the corporeal world was the result of a single creative act, having an immediate effect in the case of minerals, and a remote or postponed effect in the case of plants and animals (cf. "De Genesi ad litteram," lib. V, c. 5). Living beings, therefore, were created, not in actuality, but in germ. God imparted to the elements the power of producing the various plants and animals in their proper time and place. Hence living beings were created causally rather than formally, by the establishment of causal mechanisms or natural agencies especially ordained to bring about the initial formation of the ancestral forms of life. The Divine act initiating these "natural processes" (*rationes seminales, rationes causales*) in inorganic, and not in living, matter, was instantaneous, but the processes, which terminated in the formation of plants and animals, in their appointed time and place, were in themselves gradual and successive. Thus by an influx of Divine power the earth was made pregnant with the promise of every form of life—*"Sicut matres gravidae sunt foetibus, sic ipse mundus est gravidus causis nascentium."* (Augustine, lib. III, "de Trinitate," c. 9.)

By reason of this doctrine, the Louvain professor claims that St. Augustine was an evolutionist, and so, indeed, he was, if by evolution is meant a gradual production of organisms from inorganic matter. But if, on the contrary, by evolution is meant a progressive differentiation and multiplication of organic species by transmutation of preëxistent forms of life, or, in other words, if evolution is taken in its usual sense as synonym for transformism, then nothing could be more absurdly anachronistic than to ascribe the doctrine to St. Augustine. The subject of the gradual process postulated by the latter was, not living, but *inorganic,* matter, and the process was conceived as leading to the *formation,* and not the trans-

formation, of species. The idea of variable inheritance did not occur to St. Augustine, and he conceived organisms, once they were in existence, as being propagated exclusively by univocal reproduction (*generatio univoca*). It is the fixist, therefore, rather than the transformist, who is entitled to exploit the Augustinian hypothesis. In fact, it is only the vicious ambiguity and unlimited elasticity of the term evolution, which avail to extenuate the astounding confusion of ideas and total lack of historic sense, that can bracket together under a common term the ideology of Darwin and the view of St. Augustine.

§ 2. The Argument in the Concrete

But it is our task to criticize the theory of transformism, and not to throw a life-line to fixism, by advocating gradual formation of species as the only feasible alternative to gradual transformation of species. Perhaps, this particular life-line will not be appreciated any way; for the fixist may, not without reason, prefer to rest his case on the contention that the intrinsic *time-value* of geological formations is far too problematic for certain conclusions of any sort. In maintaining this position, he will have the support of some present-day geologists, and can point, as we shall see, to facts that seem to bear out his contention. In fact, the cogency of the palæontological argument appears to be at its maximum in the abstract, and to evaporate the moment we carry it into the concrete. The lute seems perfect, until we begin to play thereon, and then we discover certain rifts that mar the effect. It is to these rifts that our attention must now be turned.

The first and most obvious flaw, in the evolutionary interpretation of fossil series, is the confounding of succession with filiation. Thinkers, from time immemorial, have commented on the deep chasm of distinction, which divides historical from causal sequence, and philosophers have never ceased to inveigh against the sophistical snare of: *Post hoc, ergo propter hoc.* That one form of life has been subsequent

in time to another form of life is, in itself, no proof of descent. "Let us suppose," says Bather, "all written records to be swept away, and an attempt made to reconstruct English history from coins. We could set out our monarchs in true order, and we might suspect that the throne was hereditary; but if on that assumption we were to make James I, the son of Elizabeth—well, but that's just what palæontologists are constantly doing. The famous diagram of the Evolution of the Horse which Huxley used in his American lectures has had to be corrected in the light of the fuller evidence recently tabulated in a handsome volume by Prof. H. F. Osborn and his coadjutors. *Palæotherium,* which Huxley regarded as a direct ancestor of the horse, is now held to be only a collateral, as the last of the Tudors were collateral ancestors of the Stuarts. The later *Ancitherium* must be eliminated from the true line as a side branch—a Young Pretender. Sometimes an apparent succession is due to immigration of a distant relative from some other region—'The glorious House of Hanover and Protestant Succession.' It was, you will remember, by such migrations that Cuvier explained the renewal of life when a previous fauna had become extinct. He admitted succession but not descent." (*Science,* Sept. 17, 1920, p. 261.)

But, if succession does not imply descent, descent, at least, implies succession, and the fact that succession is the necessary corollary of descent, may be used as a corrective for the erroneous allocations made by neontologists on the basis of purely morphological considerations. The *priority* of a type is the *sine qua non* condition of its being accepted as *ancestral.* It is always embarrassing when, as sometimes happens, a "descendant" turns out to be older than, or even coëval with, his "ancestor." If, however, the historical position of a form can be made to coincide with its anatomical pretensions to ancestry, then the inference of descent attains to a degree of logical respectability that is impossible in the case of purely zoölogical evidence. Recent years have witnessed a more drastic application of the historical test to morphological speculations,

and the result has been a wholesale revision of former notions concerning phylogeny. "I could easily," says Bather, "occupy the rest of this hour by discussing the profound changes wrought by this conception on our classification. It is not that orders and classes hitherto unknown have been discovered, not that some erroneous allocations have been corrected, but the whole basis of our system is being shifted. So long as we were dealing with a horizontal section across the tree of life—that is to say, with an assemblage of approximately contemporaneous forms—or even with a number of such horizontal sections, so long were we confined to simple description. Any attempt to frame a causal connection was bound to be speculative." (*Ibidem,* p. 258.) Whether zoölogists will take kindly to this "shifting of the whole basis" of classification, remains to be seen. Personally, we think they would be very ill-advised to exchange the solid observational basis of homology for the scanty facts and fanciful interpretations of palæontologists.

The second stumblingblock in the path of Transformism is the occurrence of convergence. We have seen that, in the palæontological argument, descent is inferred conjointly from similarity and succession, and that, in the abstract, this argument is very persuasive. One of the concrete phenomena, however, that tend to make it inconsequential, is the undoubted occurrence of convergence. Prof. H. Woods of Cambridge, in the Introduction to the 5th edition of his "Palæontology" (1919), speaks of three kinds of convergence (cf., pp. 14, 15, 16), which, as a matter of convenience, we may term the parallelistic, the radical, and the adaptational, types of convergence. A brief description of each type will serve to elucidate its nature and its significance :

(1) Parallelistic convergence implies the appearance of parallel modifications in the homologous parts of organisms regarded as diverging from common stock in two distinct collateral lines, that were independent at the time of the appearance in both of the said parallel modifications. Speaking

of the fossil cœlenterates known as *Graptolites,* Professor Woods says: "In some genera the hydrothecæ of different species show great variety of form, those of one species being often much more like those of a species belonging to another genus than to other species of the same genus." ("Palæontology," 5th ed., 1919, p. 69.) As another instance of this phenomenon, the case of the fossil ungulates of South America, spoken of as *Litopterna,* may be cited, and the case is peculiarly interesting because of its bearing on that *pièce de résistance* of palæontological evidence, the Pedigree of the Horse. "The second family of Litopterna," says Wm. B. Scott, "the Proterotheriidæ, were remarkable for their many deceptive resemblances to horses. Even though those who contend that the Litopterna should be included in the Perissodactyla should prove to be in the right, there can be no doubt that the proterotheres were not closely related to the horses, but formed a most striking illustration of the independent acquisition of similar characters through parallel or convergent development. The family was not represented in the Pleistocene, having died out before that epoch, and the latest known members of it lived in the upper Pliocene. . . . Not that this remarkable character was due to grotesque proportions; on the contrary, they looked far more like the ordinary ungulates of the northern hemisphere than did any of their South American contemporaries; it is precisely this resemblance that is so notable. . . . The feet were three-toed, except in one genus (*Thoatherium*) in which they were single-toed, and nearly or quite the whole weight was carried upon the median digit, the laterals being mere dew-claws. The shape of the hoofs and the whole appearance of the foot was surprisingly like those of the three-toed horses, but there were certain structural differences of such great importance, in my judgment, as to forbid the reference of these animals, not merely to the horses, but even to the perissodactyls." ("A History of Land Mammals in the Western Hemisphere," p. 499.)

For this sort of parallelism, the Lamarckian and Darwinian

types of evolution by addition can offer no rational explanation. It could, perhaps, be accounted for upon the Batesonian hypothesis of evolution by loss of inhibition, that is to say, the coincident appearance of convergent characters in collateral lines might be interpreted as being due to a parallel loss in both lines of the inhibitive genes, which had suppressed the convergent feature in the primitive or common stock. We say that the convergence *might* be so interpreted, because the interpretation in question would, at best, be merely optional and not at all necessary; for in the third, or adaptational, type of convergence, we shall see instances of parallel modifications occurring in completely independent races, whose morphology and history alike exclude all possibility of hereditary connection between them. Hence, even in the present case, nothing constrains us to accept the genetic interpretation.

(2) Radical convergence, which Woods styles heterogenetic homœomorphy, is described by him as follows: "Sometimes two groups of individuals resemble each other so closely that they might be regarded as belonging to the same genus or even to *the same species* (italics mine), but they have descended from different ancestors since they are found to differ in development (ontogeny) or in their palæontological history; this phenomenon, of forms belonging to different stocks approaching one another in character, is known as convergence or heterogenetic homœomorphy, and may occur at the same geological period or at widely separated intervals. Thus the form of oyster known as *Gryphaea* has originated independently from oysters of the ordinary type in the Lias, in the Oölites, and again in the Chalk; these forms found at different horizons closely resemble one another and have usually been regarded as belonging to one genus (*Gryphaea*), but they have no direct genetic connection with one another." ("Palæontology," 5th ed., 1919, p. 15.) Comment is almost superfluous. If even *specific* resemblance is no proof of common origin, then what right have we to interpret any resemblance whatever in this sense? With such an admission, the whole bottom drops out

of the evolutionary argument. When the theory of descent is forced to account for heterogenetic resemblance at expense of all likelihood and consistency, when it cannot save itself except by blowing hot and cold with one breath, one is tempted to exclaim: "Oh, why bother with it!"

(3) Adaptational convergence is the occurrence of parallel modifications due to analogous specialization in unrelated forms, whose phylogeny has been obviously diverse. "Also, animals belonging to quite distinct groups," says Woods, "may, when living under similar conditions, come to resemble one another owing to the development of adaptive modifications, though they do not really approach one another in essential characters; thus analogous or parallel modifications may occur in independent groups—such are the resemblances between flying reptiles (*Ornithosaurs*) and birds, and between sharks, icthyosaurs and dolphins." (*Op. cit.*, p. 16.) As this type of convergence has been discussed in a previous article, with reference to the mole and mole-cricket, it need not detain us further.

All these types of convergence, but especially the second type, are factual evidence of the compatibility of resemblance with independent origin, and the fact of their occurrence tends to undermine the certainty of the phylogenetic inferences based on fossil evidence; all the more so, that, thanks to its bad state of preservation, and the impossibility of dissection, even superficial resemblances may give rise to false interpretations. And, as for the cases of radical convergence, there is no denying that they strike at the very heart of the theory of descent.

The third difficulty for Transformism arises from the discontinuity of the geological record. It was one of the very first discrepancies to be discovered between evolutionary expectation and the actual results of research. The earliest explorations revealed a state of affairs, that subsequent investigations have failed to remedy: on the one hand, namely, a notable absence of intermediate species to bridge the gaps between the fossil genera, and on the other hand, the sudden

and simultaneous appearance of numerous new and allied types unheralded by transitional forms. Since Darwin had stressed the gradualness of transmutation, the investigators expected to find the transitional means more numerous than the terminal extremes, and were surprised to find, in the real record of the past, the exact reverse of their anticipation. They found that the classes and families of animals and plants had always been as widely separated and as sharply differentiated as they are to-day, and that they had always formed distinct systems, unconnected by transitional links. The hypothetical "generalized types," supposed to combine the features of two or three families, have never been found, and most probably never will be; for it is all but certain that they never existed. Occasionally, it is true, palæontologists have discovered isolated types, which they interpreted as annectant forms, but a single pier does not make a bridge, and only too often it chanced that the so-called annectant type, though satisfactory from the morphological standpoint, was more recent than the two groups, to which it was supposed to be ancestral. But it will make matters plainer, if we illustrate what is meant by the discontinuity or incompleteness of the fossil record, by reference to some concrete series, such as the so-called Pedigree of the Horse.

Whenever a series of fossils, arranged in the order of their historical sequence, exhibits a gradation of increasing resemblance to the latest form, with which the series terminates, such a series is called a palæontological pedigree, and is said to represent so many stages in the racial development or phylogeny of the respective modern type. The classical example of this sort of "pedigree" is that of the Horse. It is, perhaps, one of the most complete among fossil "genealogies," and yet, as has been frequently pointed out, it is, as it stands, extremely incomplete. Modern representatives of the *Equidae*, namely, the horse, the ass and the zebra, belong to a common genus, and are separated from one another by differences which are merely specific, but the differences which separate

the various forms, that compose the "pedigree of the Horse," are generic. We have, to borrow Gerard's simile, nothing more than the piers of the evolutionary bridge, without the arches, and we do not know whether there ever were any arches. There is, indeed, a sort of progression, *e.g.*, from the four-toed to a one-toed type, so that the morphological gradation does, in some degree, coincide with temporal succession. But, on the other hand, the fossil forms, interpreted as stages in the phylogeny of the Horse, are separated from one another by gaps so enormous, that, in the absence of intermediate species to bridge the intervals, it is practically impossible, particularly in the light of our experimental knowledge of Genetics, to conceive of any transition between them. Nor is this all. The difficulty is increased tenfold, when we attempt to relate the *Equidae* to other mammalian groups. Fossil ungulates appear suddenly and contemporaneously in the Tertiary of North America, South America and Europe, without any transitional precursors, to connect them with the hypothetical proto-mammalian stock, and to substantiate their collaterality with other mammalian stocks.

To all such difficulties the evolutionist replies by alleging the incompleteness of the geological record, and modern handbooks on palæontology devote many pages to the task of explaining why incompleteness of the fossil record is just what we should expect, especially in the case of terrestrial animals. The reasons which they assign are convincing, but this particular mode of solving the difficulty is a rather precarious one. Evolutionists should not forget that, in sacrificing the substantial completeness of the record to account for the absence of intermediate species, they are simultaneously destroying its value as a proof of the relative position of organic types in time. Yet this, as we have seen, is precisely the feature of greatest strategic value in the palæontological "evidence" for evolution. We must have absolute *certainty* that the reputed "ancestor" was in existence prior to the appearance of the alleged "descendant," or the peculiar force of

the palæontological argument is lost. It would be preposterous for the progeny to be prior to, or even coëval with, the progenitor, and so we must be quite sure that what we call "posterity" is really posterior in time. Now the sole argument that palæontology can adduce for the posteriority of one organic type as compared with another is the negative evidence of its non-occurrence, or rather of its non-discovery, in an earlier geological formation. The lower strata do not, so far as is known, contain the type in question, and so it is concluded that this particular form had no earlier history. Such an inference, as is clear, is not only liable to be upset by later discoveries, but has the additional disadvantage of implicitly assuming the substantial completeness of the fossil record, whereas the absence of intermediate species is only explicable by means of the assumed incompleteness of the selfsame record. The evolutionist is thus placed in the dilemma of choosing between a substantially complete, and a substantially incomplete, record. Which of the alternatives, he elects, matters very little; but he must abide by the consequences of his decision, he cannot eat his cake and have it.

When the evolutionist appeals to the facts of palæontology, it goes without saying that he does so in the hope of showing that the differences, which divide modern species of plants and animals, diminish as we go backward in time, until the stage of identity is reached in the unity of a common ancestral type. Hence from the very nature of the argument, which he is engaged in constructing, he is compelled to resort to intermediate types as evidence of the continuity of allied species with the hypothetical ancestor, or common type, whence they are said to have diverged. Now, even supposing that his efforts in this direction were attended with a complete measure of success, evidence of this kind would not of itself, as we shall see, suffice to demonstrate the common origin of the extremes, between which a perfect series of intergradent types can be shown to mediate. Unquestionably, however, unless such a series of intergradent fossil species can be adduced as

evidence of the assumed transition, the presumption is totally against the hypothesis of transformism.

Now, as a matter of fact, the geological record rarely offers any evidence of the existence in the past of intermediate species. For those, who have implicit confidence in the *time-value* of geological "formations," there are indications of a general advance from lower to higher forms, but, even so, there is little to show that this seeming progress is to be interpreted as an increasing divergence from common ancestral types. With but few exceptions, the fossil record fails to show any trace of transitional links. Yet pedigrees made up of diverse genera are poor evidence for filiation or genetic continuity, so long as no intermediate species can be found to bridge the chasm of generic difference. By intermediate species, we do not mean the fabulous "generalized type." Annectants of this kind are mere abstractions, which have never existed, and never could have existed. We refer rather to actual fossil types separated from one another by differences not greater than specific; for "not until we have linked species into lineages," can fossil pedigrees lay claim to serious attention.

But let us suppose the case for evolution to be ideally favorable, and assume that in every instance we possessed a perfect gradation of forms between two extremes, such, for example, as occurs in the Ammonite series, even then we would be far from having a true demonstration of the point at issue. Bateson has called our attention to the danger of confounding sterile and instable *hybrids* with intergradent species. "Examine," he says, "any two thoroughly distinct species which meet each other in their distribution, as for instance, *Lychnis diurna* and *vespertina* do. In areas of overlap are many intermediate forms. These used to be taken to be transitional steps, and the specific distinctness of *vespertina* and *diurna* was on that account questioned. Once it is known that these supposed intergrades are merely mongrels between the two species the transition from one to the other is practically be-

yond our powers of imagination to conceive. If both these can survive, why has their common parent perished? Why, when they cross, do they not reconstruct it instead of producing partially sterile hybrids? I take this example to show how entirely the facts were formerly misrepresented." (*Heredity*, Smithson. Inst. Rpt. for 1915, p. 369.)

Similarly, T. H. Morgan has shown, with reference to *mutants*, the fallacy of inferring common descent from the phenomenon of intergradence, and what holds true for a series of intergradent mutants would presumably also hold true of a series of intergradent species, could such a series be found and critically distinguished from hybrid and mutational intermediates. In short, the Darwinian deduction of common origin from the existence of intergradence must now be regarded as a thoroughly discredited argument. "Because we can often arrange the series of structures in a line extending from the very simple to the more complex, we are apt to become unduly impressed by this fact and conclude that if we found the complete series we should find all the intermediate steps and that they have arisen in the order of their complexity. This conclusion is not necessarily correct." ("A Critique of the Theory of Evolution," p. 9.) Having cited such a series of gradational mutations ranging between the long-winged, and completely wingless condition, in the case of the Vinegar Fly (*Drosophila melanogaster*), as well as two similar graded series based on pigmentation and eye color, he concludes: "These types, with the fluctuations that occur within each type, furnish a complete series of gradations; yet historically they have arisen independently of each other. Many changes in eye color have appeared. As many as thirty or more races differing in eye color are now maintained in our cultures. Some of them are so similar that they can scarcely be separated from each other. It is easily possible beginning with the darkest eye color, sepia, which is a deep brown, to pick out a perfectly graded series ending with pure white eyes. But such a serial arrangement would give a totally false idea

of the way the different types have arisen; and any conclusion based on the existence of such a series might very well be entirely erroneous, for the fact that such a series exists bears no relation to the order in which its members have appeared." (*Op. cit.*, pp. 12, 13.) Such facts must give us pause in attaching undue importance to phenomena like the occurrence of a gradual complication of sutures in the Chalk Ammonites, particularly as parallel series of perfectly similar sutures occurs "by convergence" in the fossil Ceratites, which have no genetic connection with the Ammonites. (Cf. Woods' "Palæontology," 5th ed., p. 16.)

But, if even mutational and specific intergradents are not sufficient evidence of common ancestry, what shall we say of a discontinuous series, whose links are separate genera, orders, or even classes, instead of species. Even the most enthusiastic transformist is forced to admit the justice of our insistence that the gaps which separate the members of a series must be reduced from differences of the generic, to differences of the specific, order, before that series can command any respect as hypothetical "genealogy." "You will have observed," says F. A. Bather, "that the precise methods of the modern palæontologist, on which this proof is based, are very different from the slap-dash conclusions of forty years ago. The discovery of *Archæopteryx*, for instance, was thought to prove the evolution of birds from reptiles. No doubt it rendered that conclusion extremely probable, especially if the major promise—that evolution was the method—were assumed. But the fact of evolution is precisely what men were then trying to prove. These jumpings from class to class or from era to era, by aid of a few isolated stepping-stones, were what Bacon calls anticipations "hasty and premature but very effective, because as they are collected from a few instances, and mostly from those which are of familiar occurrence, they immediately dazzle the intellect and fill the imagination." (*Nov. Org.*, I, 28.) No secure step was taken until the modern palæontologist began to affiliate mutation with mutation and species with

species, working his way back, literally inch by inch, through a single small group of strata. Only thus could he base on the laboriously collected facts a single true interpretation; and to those who preferred the broad path of generality his interpretations seemed, as Bacon says they always "must seem, harsh and discordant—almost like mysteries of faith." . . . Thus by degrees we reject the old slippery stepping-stones that so often toppled us into the stream, and, foot by foot, we build a secure bridge over the waters of ignorance." (*Science*, Sept. 17, 1920, pp. 263, 264.)

We cannot share Bather's confidence in the security of a bridge composed of even linked species. Let such a series be never so perfect, let the gradation be never so minute, as it might conceivably be made, when not merely distinct species, but also hybrids, mutants and fluctuants are available as stop-gaps, the bare fact of such intergradation tells nothing whatever concerning the problem of genetical origin and specific relationship. The species-by-species method does, however, represent the very minimum of requirement imposed upon the palæontologist, who professes to construct a fossil pedigree. But, when all is said and done, such a method, even at its best, falls considerably short of the mark. However perfectly intergradent a series of fossils may be, the fact remains that these petrified remnants of former life cannot be subjected to breeding tests, and that, in the consequent absence of genetical experimentation, we have no means of determining the real bearing of these facts upon the problem of interspecific relationship. Only the *somatic* characters of extinct floras and faunas have been conserved in the rock record of the past, and even these are often rendered dubious, as we shall see presently, by their imperfect state of preservation. Now, it is solely in conjunction with breeding experiments, that somatic characters can give us any insight into the nature of the *germinal constitution* of an organism, which, after all, is the cardinal consideration upon which the whole question of interspecific relationship hinges. All inferences, therefore, regarding the de-

scent of fossil forms are irremediably speculative and conjectural. When we are dealing with living forms, we can always check up the inferences based on somatic characteristics by means of genetical experiments, and in so doing we have found that it is as unsafe to judge of an organism from the exclusive standpoint of its external characters as it is to judge of a book by the cover; for, apart from the check of breeding tests, it is impossible to say just which somatic characters are genetically significant, and which are not. Forms externally alike may be so unlike in germinal constitution as to be sexually incompatible; forms externally unlike may be readily crossed without any discernible diminution of fertility. "Who could have foreseen," exclaims Bateson, "that the apple and the pear —so like each other that their botanical differences are evasive—could not be crossed together, though species of *Antirrhinum* (Snapdragon) so totally unlike each other as *majus* and *molle* can be hybridized, as Baur has shown, without a sign of impaired fertility?" (*Heredity,* Smithson. Inst. Rpt. for 1915, p. 370.) We cannot distinguish between alleged specific, and merely mutational (varietal), change, nor between hybridizations and factorial, chromosomal, or pseudo-, mutations, solely on the basis of such external characters as are preserved for us in fossils. It is impossible, therefore, to demonstrate trans-specific variation by any evidence that Palæontology can supply. The palæontologist (*pace* Osborn) is utterly incompetent to pass judgment on the problem of interspecific relationship. As Bateson remarks: "In discussing the physiological problem of interspecific relationship evidence of a more stringent character is now required; and a naturalist acquainted with genetical discoveries would be as reluctant to draw conclusions as to the specific relationship of a series of fossils as a chemist would be to pronounce on the nature of a series of unknown compounds from an inspection of them in a row of bottles." (*Science,* April 17, 1922, p. 373.) "When the modern student of variation and heredity," says T. H. Morgan, "looks over the different 'continuous'

series, from which certain 'laws' and 'principles' have been deduced, he is struck by two facts: that the gaps, in some cases, are enormous as compared with the single changes with which he is familiar, and (what is more important) that they involve numerous parts in many ways. The geneticist says to the palæontologist, since you do not know, and from the nature of your case can never know, whether your differences are due to one change or to a thousand, you cannot with certainty tell us anything about the hereditary units which have made the process of evolution possible." (*Op. cit.*, pp. 26, 27.) And without accurate knowledge on this subject, we may add, there is no possibility of demonstrating specific change or genetic relationship in the case of any given fossil.

In our discussion of the third defect in the fossil "evidence," allusion was made to a fourth, namely, its imperfect state of preservation. The stone record of bygone days has been so defaced by the metamorphism of rocks, by the solvent action of percolating waters, by erosion, weathering and other factors of destruction, that, like a faded manuscript, it becomes, even apart from its actual *lacunae*, exceedingly difficult to decipher. So unsatisfactory, indeed, is the condition of the partially obliterated facts that human curiosity, piqued at their baffling ambiguity, calls upon human imagination to supply what observation itself fails to reveal. Nor does the invitation remain unheeded. Romance hastens to the rescue of uncertain Science, with an impressive display of "reconstructed fossils," and the hesitation of critical caution is superseded by the dogmatism of arbitrary assumption. Scattered fragments of fossilized bones are integrated into skeletons and clothed by the magic of creative fancy with an appropriate musculature and flesh, reënacting for us the marvelous vision of Ezekiel: "And the bones came together, each one to its joint. And I beheld and, lo, there were sinews upon them, and the flesh came upon them: and the skin was stretched over them." (Chap. XXXVII, 7, 8.) "It is also true," says Osborn (who, like Haeckel, evinces a veritable mania for "retouching" in-

complete facts), "that we know the mode of origin of the human species; our knowledge of human evolution has reached a point not only where a number of links are thoroughly known but the characters of the missing links can be very clearly predicated." (*Science,* Feb. 24, 1922.) We will not dispute his contention; for it is perfectly true, that, in each and every case, all the missing details can be so exactly predicated that the resulting description might well put to shame the account of a contemporary eyewitness. The only difficulty is that such predication is the fruit of pure imagination. Scientific reconstructions, whether in the literary, plastic, or pictorial, form, are no more scientific than historical novels are historical. Both are the outcome of a psychological weakness in the human makeup, namely, its craving for a "finished picture"—a craving, however, that is never gratified save at the expense of the fragmentary basis of objective fact.

In calling into question, however, the scientific value of the so-called "scientific reconstruction," so far as its pretensions to precision and finality are concerned, it is not our intention to discredit those tentative restorations based upon Cuvier's Law of Correlation, provided they profess to be no more than provisional approximations. Many of the structural features of organisms are physiologically interdependent, and there is frequently a close correlation among organs and organ-systems, between which no causal connection or direct physiological dependence is demonstrable. In virtue of this principle, one structural feature may connote another, in which case it would be legitimate to supply by inference any missing structure implied in the actual existence of its respective correlative. But if any one imagines that the law of correlation enables a scientist to restore the lost integrity of fossil types with any considerable degree of accuracy and finality, he greatly overestimates the scope of the principle in question. At best it is nothing more than an empirical generalization, which must not be pressed to an extent unwarranted by the inductive process, that first established it. "Certain relations of struc-

ture," says Bather, "as of cloven hoofs and horns with a ruminant stomach, were observed, but as Cuvier himself insisted, the laws based on such facts were purely empirical." (*Science*, Sept. 17, 1920, p. 258.) The palæontologist, then, is justified in making use of correlation for the purpose of reconstructing a whole animal out of a few fragmentary remains, but to look for anything like photographic precision in such "restorations" of extinct forms is to manifest a more or less complete ignorance of the nature and scope of the empirical laws, upon which they are based.

The imprudence of taking these "reconstructions" of extinct forms too seriously, however, is inculcated not merely by theoretical considerations, but by experience as well. Even in the case of the mammoth, a comparatively recent form, whose skeletal remains had been preserved more completely and perfectly than those of other fossil types, the discovery of a complete carcass buried in the ice of the Siberian "taiga" on the Beresovka river showed the existing restorations to be false in important respects. All, without exception, stood in need of revision, proving, once and for all, the inadequacy of fossil remains as a basis for exact reconstruction. E. Pfizenmayer, a member of the investigating expedition, comments on the fact as follows: "In the light of our present knowledge of the mammoth, and especially of its exterior, the various existing attempts at a restoration need important corrections. Apart from the many fanciful sketches intended to portray the exterior of the animal, all the more carefully made restorations show the faults of the skeleton, hitherto regarded as typical, on which they are based, especially the powerful semicircular and upward-curved tusks, the long tail, etc.

"As these false conceptions of the exterior of the mammoth, both written and in the form of pictures, are contained in all zoölogical and palæontological textbooks, and even in scientific monographs, it seems necessary to construct a more nearly correct picture, based on our present knowledge. I have ventured on this task, because as a member of the latest expe-

dition for mammoth remains, I was permitted not only to become acquainted with this newest find while still in its place of deposit and to take part in exhuming it, but also to visit the zoölogical museum of St. Petersburg, which is so rich in mammoth remains, for the purpose of studying the animal more in detail." (Smithson. Inst. Rpt. for 1906, pp. 321, 322.) The example is but one of many, which serve to emphasize not merely the inadequacy of the generality of palæontological restorations, but also the extreme difficulty which the palæontologist experiences in interpreting aright the partially effaced record of a vanished past.

The fifth and most critical flaw in the fossil "evidence" for evolution is to be found in the anomalies of the actual distribution of fossils in time. It is the boast of evolutionary Palaeontology that it is able to enhance the cogency of the argument from mere structural resemblance by showing, that, of two structurally allied forms, one is more ancient than the other, and may, therefore, be presumed to be ancestral to the later form. Antecedence in time is the *sine qua non* qualification of a credible ancestor, and, unless the relative priority of certain organic types, as compared with others, can be established with absolute certainty, the whole palæontological argument collapses, and the boast of evolutionary geology becomes an empty vaunt.

Whenever the appearance of a so-called annectant type is antedated by that of the two forms, which it is supposed to connect, this fact is, naturally, a deathblow to its claim of being the "common ancestor," even though, from a purely morphological standpoint, it should possess all the requisites of an ancestral type. Commenting upon the statement that a certain genus "is a truly annectant form uniting the Melocrinidae and the Platycrinidae," Bather takes exception as follows: "The genus in question appeared, so far as we know, rather late in the Lower Carboniferous, whereas both Platycrinidae and Melocrinidae were already established in Middle Silurian time. How is it possible that the far later form

should unite these two ancient families? Even a *mésalliance* is inconceivable." (*Science*, Sept. 17, 1920, p. 260.)

Certainty, therefore, with respect to the comparative antiquity of the fossiliferous strata is the indispensable presupposition of any palæontological argument attempting to show that there is a gradual approximation of ancient, to modern, types. Yet, of all scientific methods of reckoning, none is less calculated to inspire confidence, none less safeguarded from the abuses of subjectivism and arbitrary interpretation, than that by which the relative age of the sedimentary rocks is determined!

In order to date the strata of any given series with reference to one another, the palæontologist starts with the principle that, in an undisturbed area, the deeper sediments have been deposited at an earlier period than the overlying strata. Such a criterion, however, is obviously restricted in its application to local areas, and is available only at regions of outcrop, where a vertical section of the strata is visibly exposed. To trace the physical continuity, however, of the strata (if such continuity there be) from one continent to another, or even across a single continent, is evidently out of the question. Hence, to correlate the sedimentary rocks of a given region with those of another region far distant from the former, some criterion other than stratigraphy is required. To supply this want, recourse has been had to *index fossils*, which have now come into general use as age-markers and means of stratigraphical correlation, where the criterion of *superposition* is either absent or inapplicable. Certain fossil types are assumed to be infallibly indicative of certain stratigraphical horizons. In fact, when it comes to a decision as to the priority or posteriority of a given geological formation, index fossils constitute the court of last appeal, and even the evidences of actual stratigraphical sequence and of physical texture itself are always discounted and explained away, whenever they chance to conflict with the presumption that certain fossil forms are typical of certain geological periods. If, for ex-

ample, the superposed rock contains fossils alleged to be typical of an "earlier" stratigraphic horizon than that to which the fossils of the subjacent rock belong, the former is pronounced to be "older," despite the fact that the actual stratigraphic order conveys the opposite impression. "We still regard fossils," says J. W. Judd, "as the 'medals of creation,' and certain types of life we take to be as truly characteristic of definite periods as the coins which bear the image and superscription of a Roman emperor or of a Saxon king." (Cf. Smithson. Inst. Rpt. for 1912, p. 356.) Thus it comes to pass, in the last analysis, that fossils, on the one hand, are dated according to the consecutive strata, in which they occur, and strata, on the other hand, are dated according to the fossils which they contain.

Such procedure, if not actually tantamount to a *vicious circle*, is, to say the least, in imminent danger of becoming so. For, even assuming the so-called empirical generalization, that makes certain fossils typical of certain definitely-aged geological "formations," to be based upon induction sufficiently complete and analytic to insure certainty, at least, in the majority of instances, and taking it for granted that we are dealing with a case, where the actual evidence of stratigraphy is not in open conflict with that of the index fossils, who does not see that such a system of chronology lends itself only too readily to manipulation of the most arbitrary kind, whenever the pet preconceptions of the evolutionary chronologist are at stake? How, then, can we be sure, in a given case, that a verdict based exclusively on the "evidence" of index fossils will be reliably *objective?* It is to be expected that the evolutionist will refrain from the temptation to give himself the benefit of every doubt? Will there not be an almost irresistible tendency on the part of the convinced transformist to revise the age of any deposit, which happens to contain fossils that, according to his theory, ought not to occur at the time hitherto assigned?

The citation of a concrete example will serve to make our

meaning clear. A series of fresh-water strata occur in India known as the Siwalik beds. The formation in question was originally classed as Miocene. Later on, however, as a result, presumably, of the embarrassing discovery of the genus *Equus* among the fossils of the Upper Siwalik beds, Wm. Blanford saw fit to mend matters by distinguishing the Upper, from the Lower, beds and assigning the former (which contain fossil horses) to the Pliocene period. The title Miocene being restricted by this ingenious step to beds destitute of equine remains, namely the Nahun, or Lower Siwalik, deposits, all danger of the horse proving to be older than his ancestors was happily averted. A mere shifting of the conventional labels, apparently, was amply sufficient to render groundless the fear, to which Professor A. Sedgwick had given expression in the following terms: "The genus *Equus* appears in the upper Siwalik beds, which have been ascribed to the Miocene age. . . . If *Equus* really existed in the Upper Miocene, it was antecedent to some of its supposed ancestors." ("Students' Textbook of Zoölogy," p. 599.) Evidently, the Horse must reconcile himself perforce to the pedigree assigned to him by the American Museum of Natural History; for he is to be given but scant opportunity of escaping it. This classic genealogy has already entailed far too great an expenditure of time, money and erudition to permit of any reconsideration; and should it chance, in the ironic perversity of things, that the Horse has been so inconsiderate as to leave indubitable traces of himself in any formation earlier than the Pliocene, it goes without saying that the formation in question will at once be dated ahead, in order to secure for the "ancestors" that priority which is their due. An elastic criterion like the index fossil is admirably adapted for readjustments of this sort, and the evolutionist who uses it need never fear defeat. The game he plays can never be a losing one, because he gives no other terms than: Heads I win, tails you lose.

In setting forth the foregoing difficulties, we have purposely refrained from challenging the cardinal dogma of orthodox

palæontology concerning the unimpeachable time-value of index fossils as age-markers. The force of these considerations, therefore, must be acknowledged even by the most fanatical adherents of the aforesaid dogma. Our forbearance in this instance, however, must not be construed as a confession that the dogma in question is really unassailable. On the contrary, not only is it not invulnerable, but there are many and weighty reasons for rejecting it lock, stock, and barrel.

The palæontological dogma, to which we refer, is reducible to the following tenets: (1) The earth is swathed with fossiliferous strata, in much the same fashion that an onion is covered with a succession of coats, and these strata are universal over the whole globe, occurring always in the same invariable order and characterized not by any peculiar uniformity of external appearance, physical texture, or mineral composition, but solely by peculiar groups of fossil types, which enable us to distinguish between strata of different ages and to correlate the strata of one continent with their counterparts in another continent—"Even the minuter divisions," says Scott, "the substages and zones of the European Jura, are applicable to the classification of the South American beds." ("Introduction to Geology," p. 681.) (2) In determining the relative age of a given geological formation, its characteristic fossils form the exclusive basis of decision, and all other considerations, whether lithological or stratigraphic, are subordinated to this—"The character of the rocks," says H. S. Williams, "their composition or their mineral contents have nothing to do with settling the question as to the particular system to which the new rocks belong. The fossils alone are the means of correlation." ("Geological Biology," pp. 37, 38.)

To those habituated to the common notion that stratigraphical sequence is the foremost consideration in deciding the comparative age of rocks, the following statement of Sir Archibald Geikie will come as a distinct shock: "We may even demonstrate," he avers, "that in some mountainous ground the strata have been turned completely upside down, if we can

show that the fossils in what are now the uppermost layers ought properly to lie underneath those in the beds below them." ("Textbook," ed. of 1903, p. 837.) In fact, the palæontologist, H. A. Nicholson, lays it down as a general principle that, wherever the physical evidence (founded on stratigraphy and lithology) is at variance with the biological evidence (founded on the presence of typical fossil organisms), the latter must prevail and the former must be ignored: "It may even be said," he tells us, "that in any case where there should appear to be a clear and decisive discordance between the physical and the palæontological evidence as to the age of a given series of beds, it is the former that is to be distrusted rather than the latter." ("Ancient Life History of the Earth," p. 40.)

George McCready Price, Professor of Geology at a denominational college in Kansas, devotes more than fifty pages of his recent work, "The New Geology" (1923), to an intensely destructive criticism of this dogma of the supremacy of fossil evidence as a means of determining the relative age of strata. To cite Price as an "authority" would, of course, be futile. All orthodox geologists have long since anathematized him, and outlawed him from respectable geological society. Charles Schuchert of Yale refers to him as "a fundamentalist harboring a geological nightmare." (*Science,* May 30, 1924, p. 487.) Arthur M. Miller of Kentucky University speaks of him as "the man who, while a member of no scientific body and absolutely unknown in scientific circles, has . . . had the effrontery to style himself a 'geologist.'" (*Science,* June 30, 1922, pp. 702, 703.) Miller, however, is just enough to admit that he is well-informed on his subject, and that he possesses the gift of persuasive presentation. "He shows," says Miller, "a wide familiarity with geological literature, quoting largely from the most eminent authorities in this country and in Europe. Any one reading these writings of Price, which possess a certain charm of literary style, and indicate on the part of the author a gift of popular presentation which makes

one regret that it had not been devoted to a more laudable purpose, must constantly marvel at the character of mind of the man who can so go into the literature of the subject and still continue to hold such preposterous opinions." (*Loc. cit.*, p. 702.)

In the present instance, however, our interest centers, not on the unimportant question of his official status in geological circles, but exclusively on the objective validity of his argument against the chronometric value of the index fossil. All citations, therefore, from his work will be supported, in the sequel, by collateral testimony from other authors of recognized standing. It is possible, of course, to inject irrelevant issues. Price, for example, follows Sir Henry Holworth in his endeavor to substitute an aqueous catastrophe for the glaciation of the Quaternary Ice Age, and he adduces many interesting facts to justify his preference for a deluge. But this is neither here nor there; for we are not concerned with the merits of his "new catastrophism." It is his opportune revival in modern form of the forgotten, but extremely effective, objection raised by Huxley and Spencer against the alleged universality of synchronously deposited fossiliferous sediments, that constitutes our sole preoccupation here. It is Price's merit to have shown that, in the light of recently discovered facts, such as "deceptive conformities" and "overthrusts," this objection is far graver than it was when first formulated by the authors in question.

Mere snobbery and abuse is not a sufficient answer to a difficulty of this nature, and we regret that men, like Schuchert, have replied with more anger than logic. The orthodox geologist seems unnecessarily petulant, whenever he is called upon to verify or substantiate the foundational principles of lithic chronology. One frequently hears him make the excuse that "geology has its own peculiar method of proof." To claim exemption, however, from the universal criterions of criticism and logic is a subterfuge wholly unworthy of a genuine science, and, if Price insists on discussing a subject, which the ortho-

dox geologist prefers to suppress, it is the latter, and not the former, who is really reactionary.

Price begins by stating the issue in the form of a twofold question: (1) How can we be sure, with respect to a given fauna (or flora), say the Cambrian, that at one time it monopolized our globe to the complete exclusion of all other typical faunas (or floras), say the Devonian, or the Tertiary, of which it is assumed that they could not, by any stretch of imagination, have been contemporaneous, on either land or sea, with the aforesaid "older" fauna (or flora)? (2) Do the formations (rocks containing fossils) universally occur in such a rigidly invariable order of sequence with respect to one another, as to warrant our being sure of the starting-point in the time-scale, or to justify us in projecting any given local order of succession into distant localities, for purposes of chronological correlation?

His response to the first of these questions constitutes what may be called an aprioristic refutation of the orthodox view, by placing the evolutionary palæontologist in the trilemma: (a) of making the awkward confession that, except within limited local areas, he has no means whatever of distinguishing between a geographical distribution of coëval fossil forms among various habitats and a chronological distribution of fossils among sediments deposited at different times; (b) or of denying the possibility of geographical distribution in the past, by claiming dogmatically that the world during Cambrian times, for example, was totally unlike the modern world, of which alone we have experimental knowledge, inasmuch as it was then destitute of zoölogical provinces, districts, zones, and other habitats peculiar to various types of fauna, so that the whole world formed but one grand habitat, extending over land and sea, for a limited group of organisms made up exclusively of the lower types of life; (c) or of reviving the discredited onion-coat theory of Abraham Werner under a revised biological form, which asserts that the whole globe is enveloped with fossiliferous rather

than mineral strata, whose order of succession being everywhere the same enables us to discriminate with precision and certainty between cases of distribution in time and cases of distribution in space.

In his response to the second question, Professor Price adduces numerous factual arguments, which show that the invariable order of sequence postulated by the theory of the time-value of index fossils, not only finds no confirmation in the actual or concrete sequences of fossiliferous rocks, but is often directly contradicted thereby. "Older" rocks may occur above "younger" rocks, the "youngest" may occur in immediate succession to the "oldest," Tertiary rocks may be crystalline, consolidated, and "old in appearance," while Cambrian and even pre-Cambrian rocks sometimes occur in a soft, incoherent condition, that gives them the physical appearance of being as young as Pleistocene formations. These exceptions and objections to the "invariable order" of the fossiliferous strata accumulate from day to day, and it is only by means of Procrustean tactics of the most drastic sort that the facts can be brought into any semblance of harmony with the current dogmas, which base geology upon evolution rather than evolution upon geology.

Price, then, proposes for serious consideration the possibility that Cretaceous dinosaurs and even Tertiary mammals may have been living on the land at the same time that the Cambrian graptolites and trilobites were living in the seas. "Who," he exclaims, "will have the hardihood, the real dogmatism to affirm in a serious way that Cambrian animals and seaweeds were for a long time the only forms of life existing anywhere on earth?" Should we, nevertheless, make bold enough to aver that for countless centuries a mere few of the lower forms of life monopolized our globe, as one universal habitat unpartitioned into particular biological provinces or zones, we are thereupon confronted with two equally unwelcome alternatives. We must either fly in the face of experience and legitimate induction by denying the existence in the past of

anything analogous to our present-day geographical distribution of plants and animals into various biological provinces, or be prepared to show by what infallible criterion we are enabled to distinguish between synchronously deposited formations indicative of a geographical distribution according to regional diversity, and consecutively deposited formations indicative of comparative antiquity.

The former alternative does not merit any consideration whatever. The latter, as we shall presently see, involves us in an assumption, for which no defense either aprioristic or factual is available. We can, indeed, distinguish between spatial, and temporal, distribution within the narrow limits of a single locality by using the criterion of superposition; for in regions of outcrop, where one sedimentary rock overlies another, the obvious presumption is that the upper rock was deposited at a later date than the lower rock. But the criterion of superposition is not available for the correlation of strata in localities so distant from each other that no physical evidence of stratigraphic continuity is discernible. Moreover the induction, which projects any local order of stratigraphical sequence into far distant localities on the sole basis of fossil taxonomy, is logically unsound and leads to conclusions at variance with the actual facts. Hence the alleged time-value of index fossils becomes essentially problematic, and affords no basis whatever for scientific certainty.

As previously stated, the sequence of strata is visible only in regions of outcrop, and nowhere are we able to see more than mere parts of two or, at most, three systems associated together in a single locality. Moreover, each set of beds is of limited areal extent, and the limits are frequently visible to the eye of the observer. In any case, their visible extent is necessarily limited. It is impossible, therefore, to correlate the strata of one continent with those of another continent by tracing stratigraphic continuity. Hence, in comparing particular horizons of various ages and in distinguishing them from other horizons over large areas, we are obliged to sub-

stitute induction for direct observation. Scientific induction, however, is only valid when it rests upon some universal uniformity or invariable sequence of nature. Hence, to be specific, the assumption that the time-scale based on the European classification of fossiliferous strata is applicable to the entire globe as a whole, is based on the further assumption that we are sure of the universality of fossiliferous stratification over the face of the earth, and that, as a matter of fact, fossils are always and everywhere found in the same order of invariable sequence.

But this is tantamount to reviving, under what Spencer calls "a transcendental form," the exploded "onion-coat" hypothesis of Werner (1749-1817). Werner conceived the terrestrial globe as encircled with successive mineral envelopes, basing his scheme of universal stratification upon that order of sequence among rocks, which he had observed within the narrow confines of his native district in Germany. His hypothesis, after leading many scientists astray, was ultimately discredited and laughed out of existence. For it finally became evident to all observers that Werner's scheme did not fit the facts, and men were able to witness with their own eyes the simultaneous deposition, in separate localities, of sediments which differed radically in their mineral contents and texture. Thus it came to pass that this classification of strata according to their mineral nature and physical appearance lost all value as an absolute time-scale, while the theory itself was relegated to the status of a curious and amusing episode in the history of scientific fiascos.

Thanks, however, to Wm. Smith and to Cuvier, the discarded onion-coat hypothesis did not perish utterly, but was rehabilitated and bequeathed to us in a new and more subtle form. Werner's fundamental idea of the universality of a given kind of deposit was retained, but his mineral strata were replaced by fossiliferous strata, the lithological onion-coats of Werner being superseded by the biological onion-coats of our modern theory. The geologist of today discounts physical

appearance, and classifies strata according to their fossil, rather than their mineral, contents, but he stands committed to the same old postulate of universal deposits. He has no hesitation in synchronizing such widely-scattered formations as the Devonian deposits of New York State, England, Germany, and South America. He pieces them all together as parts of a single system of rocks. He has no misgiving as to the universal applicability of the European scheme of stratigraphic classification, but assures us, in the words of the geologist, Wm. B. Scott, that: "Even the minuter divisions, the subdivisions and zones of the European Jura, are applicable to the classification of the South American beds." ("Introduction to Geology," p. 681f.) The limestone and sandstone strata of Werner are now things of the past, but, in their stead, we have, to quote the criticism of Herbert Spencer, "groups of formations which everywhere succeed each other in a given order, and are severally everywhere of the same age. Though it may not be asserted that these successive systems are universal, yet it seems to be tacitly assumed that they are so. . . . Though probably no competent geologist would contend that the European classification of strata is applicable to the globe as a whole, yet most, if not all geologists, write as though it were so. . . . Must we not say that though the onion-coat hypothesis is dead, its spirit is traceable, under a transcendental form, even in the conclusions of its antagonists." ("Illustrations of Universal Progress," pp. 329-380, ed. of 1890.)

But overlooking, for the moment, the mechanical absurdity involved in the notion of a regular succession of universal layers of sediment, and conceding, for the sake of argument, that the substitution of fossiliferous, for lithological, strata may conceivably have remedied the defects of Werner's geological time-scale, let us confine ourselves to the one question, which, after all, is of prime importance, whether, namely, without the aid of Procrustean tactics, the actual facts of geology can be brought into alignment with the doctrine of

an invariable order of succession among fossil types, and its sequel, the intrinsic time-value of index fossils. The question, in other words, is whether or not a reliable time-scale can be based on the facts of fossiliferous stratification as they are observed to exist in the concrete. Price's answer is negative, and he formulates several empirical laws to express the concrete facts, on which he bases his contention. The laws and facts to which he appeals may be summarized as follows:

1. The concrete facts of geology do not warrant our singling out any fossiliferous deposit as unquestionably the oldest, and hence we have no reliable *starting-point* for our time-scale, because:

(*a*) We may lay it down as an empirical law that "any kind of fossiliferous rock (even the 'youngest'), that is, strata belonging to any of the systems or other subdivisions, may rest directly upon the Archæan or primitive crystalline rocks, without any other so-called 'younger' strata intervening; also these rocks, Permian, Cretaceous, Tertiary, or whatever thus reposing directly on the Archæan may be themselves crystalline or wholly metamorphic in texture. And this applies not alone to small points of contact, but to large areas."

(*b*) Conversely: any kind of fossiliferous strata (even the "oldest") may not only constitute the surface rocks over wide areas,[1] but may consist of loose, unconsolidated materials, thus in both position and texture resembling the "late" Tertiaries or the Pleistocene—"In some regions, notably in the Baltic province and in parts of the United States," says John Allen Howe, alluding to the Cambrian rocks around the Baltic

[1] "It is a common occurrence," says Charles Schuchert, "on the Canadian Shield to find the Archæozoic formations overlain by the most recent Pleistocene glacial deposits, and even these may be absent. It appears as if in such places no rocks had been deposited, either by the sea or by the forces of the land, since Archæozoic time, and yet geologists know that the shield has been variously covered by sheets of sediments formed at sundry times in the Proterozoic, Palæozoic, and, to a more limited extent, in the Mesozoic." ("Text-book of Geology," ed. of 1920, II, p. 569.) It may be remarked that, when geologists "know" such things, they know them in spite of the facts!

Sea and in Wisconsin, "the rocks still retain their original horizontality of deposition, the muds are scarcely indurated, and the sands are incoherent." (Encycl. Brit., vol. V, p. 86.)

A large number of striking instances are cited by Price to substantiate the foregoing rule and its converse. The impression left is that not only is the starting-point of the time-scale in doubt, but that, if we were to judge the age of the rocks by their physical appearance and position, we could not accept the conventional verdicts of modern geology, which makes fossil evidence prevail over every other consideration.

2. When two contiguous strata are parallel to each other, and there is no indication of disturbance in the lower bed, nor any evidence of erosion along the plane of contact, the two beds are said to exhibit conformity, and this is ordinarily interpreted by geologists as a sign that the upper bed has been laid down in immediate sequence to the lower, and that there has been a substantial continuity of deposition, with no long interval during which the lower bed was exposed as surface to the agents of erosion. When such a conformity exists, as it frequently does, between a "recent" stratum, above, and what is said (according to the testimony of the fossils) to be a very "ancient" stratum, below, and though the two are so alike lithologically as to be mistaken for one and the same formation, nevertheless, such a conformity is termed a "non-evident disconformity," or "deceptive conformity," implying that, inasmuch as the "lost interval," representing, perhaps, a lapse of "several million years," is entirely unrecorded by any intervening deposition, or any erosion, or any disturbance of the lower bed, we should not have suspected that so great a hiatus had intervened, were it not for the testimony of the fossils. Price cites innumerable examples, and sums them up in the general terms of the following empirical law: "Any sort of fossiliferous formation may occur on top of any other 'older' fossiliferous formation, with all the physical evidences of perfect conformity, just

as if these alleged incongruous or mismated formations had in reality followed one another in quick succession."

A quotation from Schuchert's "Textbook of Geology," (1920), may be given by way of illustration: "The imperfection," we read, "of the geologic column is greatest in the interior of North America and more so in the north than in the south. This imperfection is in many places very marked, since an entire period or several periods may be absent. With such great breaks in the local sections the natural assumption is that these gaps are easily seen in the sequence of the strata, but in many places the beds lie in such perfect conformity upon one another that the breaks are not noticeable by the eye and can be proved to exist only by the entombed fossils on each side of a given bedding plane. . . . Stratigraphers are, as a rule, now fully aware of the imperfections in the geologic record, but the rocks of two unrelated formations may rest upon each other with such absolute conformability as to be completely deceptive. For instance, in the Bear Grass quarries at Louisville, Ky., a face of limestone is exposed in which the absolute conformability of the beds can be traced for nearly a mile, and yet within 5 feet of vertical thickness is found a Middle Silurian coral bed overlain by another coral zone of Middle Devonian. The parting between these two zones is like that between any two limestone beds, but this insignificant line represents a stratigraphic hiatus the equivalent of the last third of Silurian and the first of Devonian time. But such disconformities are by no means rare, in fact are very common throughout the wide central basin area of North America." (*Op. cit.*, II, pp. 586-588.)

In such cases, the stratigraphical relations give no hint of any enormous gap at the line of contact. On the contrary, there is every evidence of unbroken sequence, and the physical appearances are as if these supposed "geological epochs" had never occurred in the localities, of which there is question. Everything points to the conclusion that the alleged long intervals of time between such perfectly conformable, and,

often, lithologically identical, formations are a pure fiction elaborated for the purpose of bolstering up the dogma of the universal applicability of the European classification of fossiliferous rocks. Why not take the facts as we find them? Why resort to tortuous explanations for the mere purpose of saving an arbitrary time-scale? Why insist on a definite time-value for fossils, when it drives us to the extremity of discrediting the objective evidence of physical facts in deference to the preconceptions of orthodox geology? Were it not for theoretical considerations, these stratigraphic facts would be taken at their face value, and the need of saving the reputation of the fossil as an infallible time index is not sufficiently imperative to warrant so drastic a revision of the physical evidence.

3. The third class of facts militating against the time-value of index fossils, are what Price describes as "deceptive conformities turned upside down," and what orthodox geology tries to explain away as "thrusts," "thrust faults," "overthrusts," "low-angle faulting," etc.[2] In instances of this kind we find the accepted order of the fossiliferous strata reversed in such a way that the "younger" strata are conformably overlain by "older" strata, and the "older" strata are sometimes interbedded between "younger" strata. "In many places all over the world," says Price, "fossils have been found in a relative order which was formerly thought to be utterly impossible. That is, the fossils have been found in the 'wrong' order, and on such a scale that there can be no mistake about it. For when an area 500 miles long

[2] Thus, to explain away "wrong sequences" of fossils, Heim and Rothpletz postulate the great Glaurus overthrust in the Alps, Geikie the great overthrust in Scotland, McConnell, Campbell, and Willis a great overthrust along the eastern front of the Rockies in Montana and Alberta, while Hayes recognizes numerous overthrusts in the southern Appalachians. "The deciphering of such great displacements," says Pirrson, speaking of thrust faults, "is one of the greatest triumphs of modern geological research." ("Textbook of Geology," 1920, I, p. 367.) Desperate measures are evidently justifiable, when it is a question of saving the time-value of fossils!

and from 20 to 50 miles wide is found with Palæozoic rocks on top, or composing the mountains, and with Cretaceous beds underneath, or composing the valleys, and running under these mountains all around, as in the case of the Glacier National Park and the southern part of Alberta, the old notion about the exact and invariable order of the fossils has to be given up entirely."

Price formulates his third law as follows: "Any fossiliferous formation, 'old' or 'young,' may occur conformably on any other fossiliferous formation, 'younger' or 'older.' " The corollary of this empirical law is that we are no longer justified in regarding any fossils as intrinsically older than other fossils, and that our present classification of fossiliferous strata has a *taxonomic,* rather than a *historical,* value.

Low-angle faulting is the phenomenon devised by geologists to meet the difficulty of "inverted sequence," when all other explanations fail. Immense mountain masses are said to have been detached from their roots and pushed horizontally over the surface (without disturbing it in the least), until they came finally to rest in perfect conformity upon "younger" strata, so that the plane of slippage ended by being indistinguishable from an ordinary horizontal bedding plane. These gigantic "overthrusts" or "thrust faults" are a rather unique phenomenon. Normal faulting is always at a high angle closely approaching the vertical, but "thrust faults" are at a low angle closely approximating the horizontal, and there is enormous displacement along the plane of slippage. The huge mountain masses are said to have been first lifted up and then thrust horizontally for vast distances, sometimes for hundreds of miles, over the face of the land, being thus pushed over on top of "younger" rocks, so as to repose upon the latter in a relation of perfectly conformable superposition. R. G. McConnell, of the Canadian Survey, comments on the remarkable similarity between these alleged "thrust planes" and ordinary stratification planes, and he is at a loss to know why the surface soil

was not disturbed by the huge rock masses which slid over it for such great distances. Speaking of the Bow River Gap, he says: "The fault plane here is nearly horizontal, and the two formations, viewed from the valley appear to succeed one another conformably," and then having noted that the underlying Cretaceous shales are "very soft," he adds that they "have suffered little by the sliding of the limestones over them." (*An. Rpt.* 1886, part D., pp. 33, 34, 84.) *Credat Iudaeus Apella, non ego!*

Schuchert describes the Alpine overthrust as follows: "The movement was both vertical and thrusting from the south and southeast, from the southern portion of Tethys, elevating and folding the Tertiary and older strata of the northern areas of this mediterranean into overturned, recumbent, and nearly horizontal folds, and pushing the southern or Lepontine Alps about 60 miles to the northward into the Helvetic region. Erosion has since carved up these overthrust sheets, leaving remnants lying on foundations which belong to a more northern portion of the ancient sea. Most noted of these residuals of overthrust masses is the Matterhorn, a mighty mountain without roots, a stranger in a foreign geologic environment," (Pirsson & Schuchert's "Textbook of Geology," 1920, II, p. 924.)

With such a convenient device as the "overthrust" at his disposal, it is hard to see how any possible concrete sequence of fossiliferous strata could contradict the preconceptions of an evolutionary geologist. The hypotheses and assumptions involved, however, are so tortuous and incredible, that nothing short of fanatical devotion to the theory of transformism can render them acceptable. "Examples," says Price, "of strata in the 'wrong' order were first reported from the Alps nearly half a century ago. Since that time, whole armfuls of learned treatises in German, in French, and in English have been written to explain the wonderful conditions there found. The diagrams that have been drawn to account for the strange order of the strata are worthy to rank with the similar ones

by the Ptolemaic astronomers picturing the cycles and epicycles required to explain the peculiar behavior of the heavenly bodies in accordance with the geocentric theory of the universe then prevailing. . . . In Scandinavia, a district some 1,120 miles long by 80 miles wide is alleged to have been pushed horizontally eastward 'at least 86 miles.' (Schuchert.) In Northern China, one of these upside down areas is reported by the Carnegie Research Expedition to be 500 miles long." ("The New Geology," 1923, pp. 633, 634.)

Nor are the epicyclic subterfuges of the evolutionary geologist confined to "deceptive conformities" and "overthrusts." His inventive genius has hit upon other methods of explaining away inconvenient facts. When, for example, "younger" fossils are found interbedded with "older" fossils, and the discrepancy in time is not too great, he rids himself of the difficulty of their premature appearance by calling them a "pioneer colony." Similarly, when a group of "characteristic" fossils occur in one age, skip another "age," and recur in a third, he recognizes the possibility of "recurrent faunas," some of these faunas having as many as five successive "recurrences." Clearly, the assumption of gradual approximation and the dogma that the lower preceded the higher forms of life are things to be saved at all costs, and it is a foregone conclusion that no facts will be suffered to conflict with these irrevisable articles of evolutionary faith. "What is the use," exclaims Price, "of pretending that we are investigating a problem of natural science, if we already know beforehand that the lower and more generalized forms of animals and plants came into existence first, and the higher and the more specialized came only long afterwards, and that specimens of all these successive types have been pigeonholed in the rocks in order to help us illustrate this wonderful truth?" (*Op. cit.*, pp. 667, 668.)

The predominance of extinct species in certain formations is said to be an independent argument of their great age. Most of the species of organisms found as fossils in Cambrian,

Ordovician, and Silurian rocks are extinct, whereas modern types abound in Cretaceous and Tertiary rocks. Hence it is claimed that the former must be vastly older than the latter. But this argument gratuitously assumes the substantial perfection of the stone record of ancient life and unwarrantedly excludes the possibility of a sudden impoverishment of the world's flora and fauna as the result of a sweeping catastrophe, of which our present species are the fortunate survivors. Now the fact that certain floras and faunas skip entire systems of rocks to reappear only in later formations is proof positive that the record of ancient life is far from being complete, and we have in the abundant fossil remains of tropical plants and animals, found in what are now the frozen arctic regions, unmistakable evidence of a sudden catastrophic change by which a once genial climate "was abruptly terminated. For carcasses of the Siberian elephants were frozen so suddenly and so completely that the flesh has remained untainted." (Dana.) Again, the mere *fact* of extinction tells us nothing about the *time* of the extinction. For this we are obliged to fall back on the index fossil whose inherent time-value is based on the theory of evolution and not on stratigraphy. Hence the argument from extinct species is not an independent argument.

To sum up, therefore, the aprioristic evolutional series of fossils is not a genuine time-scale. The only safe criterion of comparative age is that of stratigraphic superposition, and this is inapplicable outside of limited local areas.[3] The index fossil is a reliable basis for the chronological correlation of beds only in case one is already convinced on other grounds of the actuality of evolution, but for the unbiased inquirer it is destitute of any inherent time-value. In other words, we can no longer be sure that a given formation is old merely because it happens to contain Cambrian fossils, nor that a rock is young merely because it chances to contain Tertiary fos-

[3] "All that geology can prove," says Huxley, "is local order of succession." ("Discourses Biological and Geological," pp. 279-288.)

sils. Our present classification of rocks according to their fossil contents is purely arbitrary and artificial, being tantamount to nothing more than a mere taxonomical classification of the forms of ancient life on our globe, irrespective of their comparative antiquity. This scheme of classification is, indeed, universally applicable, and places can usually be found in it for new fossiliferous strata, whenever and wherever discovered. Its universal applicability, however, is due not to any prevalent order of invariable sequence among fossiliferous strata, but solely to the fact that the laws of biological taxonomy and ecology are universal laws which transcend spatial and temporal limitation. If a scheme of taxonomy is truly scientific, all forms of life, whether extant or extinct, will fit into it quite readily.

The anomalies of spatial distribution constitute a sixth difficulty for transformistic palæontology. In constructing a phylogeny the most diverse and widely-separated regions are put under tribute to furnish the requisite fossils, no heed being paid to what are now at any rate impassable geographical barriers, not to speak of the climatic and environmental limitations which restrict the migrations of non-cosmopolitan species within the boundaries of narrow habitats. Hypothetical lineages of a modern form of life are frequently constructed from fossil remains found in two or more continents separated from one another by immense distances and vast oceanic expanses. When taxed with failure to plausibleize this procedure, the evolutionist meets the difficulty by hypothecating wholesale and devious migrations to and fro, and by raising up alleged land bridges to accommodate plants and animals in their suppositional migrations from one continent to another, etc.

The European horse, with his so-called ancestry interred, partly in the Tertiary deposits of Europe, but mostly in those of North America, is a typical instance of these anomalies in geographical distribution. It would, of course, be preposterous to suppose that two independent lines of descent could

have fortuitously terminated in the production of one and the same type, namely, the genus *Equus*. Moreover, to admit for a moment that the extinct American *Equus* and the extant European *Equus* had converged by similar stages from distinct origins would be equivalent, as we have seen, to a surrender of the basic postulate that structural similarity rests on the principle of inheritance. Nothing remains, therefore, but to hypothecate a Tertiary land bridge between Europe and North America.

Modern geologists, however, are beginning to resent these arbitrary interferences with their science in the interest of biological theories. Land bridges, they rightly insist, should be demonstrated by means of positive geological evidence and not by the mere exigencies of a hypothetical genealogy. Whosoever postulates a land bridge between continents should be able to adduce solid reasons, and to assign a mechanism capable of accomplishing the five-mile uplift necessary to bring a deep-sea bottom to the surface of the hydrosphere. Such an idea is extravagant and not to be easily entertained in our day, when geologists are beginning to understand the principle of *isostasy*. To-day, the crust of the earth, that is, the entire surface of the lithosphere, is conceived as being constituted of earth columns, all of which rest with equal weight upon the level of complete compensation, which exists at a depth of some 76 miles below land surfaces. At this depth viscous flows and undertows of the earth take place, compensating all differences of gravitational stress. Hence the materials constituting a mountain column are thought to be less dense than those constituting the surrounding lowland columns, and for this reason the mountains are buoyed up above the surrounding landscape. The columns under ocean bottoms, on the contrary, are thought to consist of heavy materials like basalt, which tend to depress the column. To raise a sea floor, therefore, some means of producing a dilatation of these materials would have to be available. Arthur B. Coleman called attention to this difficulty in his Presidential

Address to the Geological Society of America (December 29, 1915), and we cannot do better than quote his own statement of the matter here:

"Admitting," he says, "that in the beginning the lithosphere bulged up in places, so as to form continents, and sagged in other places, so as to form ocean beds, there are interesting problems presented as to the permanence of land and seas. All will admit marginal changes affecting large areas, but these encroachments of the sea on the continents and the later retreats may be of quite a subordinate kind, not implying an interchange of deep-sea bottoms and land surfaces. The essential permanence of continents and oceans has been firmly held by many geologists, notably Dana among the older ones, and seems reasonable; but there are geologists, especially palæontologists, who display great recklessness in rearranging land and sea. The trend of a mountain range, or the convenience of a running bird, or a marsupial afraid to wet his feet seems sufficient warrant for hoisting up any sea bottom to connect continent with continent. A Gondwana Land arises in place of an Indian Ocean and sweeps across to South America, so that a spore-bearing plant can follow up an ice age; or an Atlantis ties New England to Old England to help out the migrations of a shallow-water fauna; or a 'Lost Land of Agulhas' joins South Africa and India.

"It is curious to find these revolutionary suggestions made at a time when geodesists are demonstrating that the earth's crust over large areas, and perhaps everywhere, approaches a state of isostatic equilibrium, and that isostatic compensation is probably complete at a depth of only 76 miles" . . . and (having noted the difference of density that must exist between the continental, and submarine, earth columns) Coleman would have us bear in mind "that to transform great areas of sea bottom into land it would be necessary either to expand the rock beneath by several per cent or to replace heavy rock, such as basalt, by lighter materials, such as granite. There is no obvious way in which the rock beneath a

sea bottom can be expanded enough to lift it 20,000 feet, as would be necessary in parts of the Indian Ocean, to form a Gondwana land; so one must assume that light rocks replace heavy ones beneath a million square miles of ocean floor. Even with unlimited time, it is hard to imagine a mechanism that could do the work, and no convincing geological evidence can be brought forward to show that such a thing ever took place. . . . The distribution of plants and animals should be arranged for by other means than by the wholesale elevation of ocean beds to make dry land bridges for them." (Smithson. Inst. Rpt. for 1916, pp. 269-271.)

A seventh anomaly of palæontological phylogeny is what may be described as contrariety of direction. We are asked to believe, for example, that in mammals racial development resulted in dimensional increase. The primitive ancestor of mammoths, mastodons, and elephants is alleged to have been the *Moeritherium,* "a small tapirlike form, from the Middle Eocene Qasr-el-Sagha beds of the Fayûm in Egypt. . . . *Moeritherium* measured about 3½ feet in height." (Lull: Smithson. Inst. Rpt. for 1908, pp. 655, 656.) The ancestor of the modern horse, we are told, was "a little animal less than a foot in height, known as *Eohippus,* from the rocks of the Eocene age." (Woodruff: "Foundations of Biology," p. 361.) In the case of insects, on the other hand, we are asked to believe the exact reverse, namely, that racial development brought about dimensional reduction. "In the middle of the Upper Carboniferous periods," says Anton Handlirsch, "the forest swamps were populated with cockroaches about as long as a finger, dragonfly-like creatures with a wing spread of about 2½ feet, while insects that resemble our May flies were as big as a hand. ("Die fossilen Insekten, und die Phylogenie der recenten Formen," 1908, L. c., p. 1150.) Contrasting one of these giant palæozoic dragonflies, *Meganeura monyi* Brongn., with the largest of modern dragonflies, *Aeschna grandis* L., Chetverikov exclaims with reference to the latter: "What a pitiful pigmy it is and its specific name (*grandis*) sounds like

such a mockery." (Smithson. Inst. Rpt. for 1918, p. 446.) Chetverikov, it is true, proposes a teleological reason for this progressive diminution, but the fact remains that for dysteleological evolutionism, which dispenses with the postulate of a Providential coördination and regulation of natural agencies, this *diminuendo* of the "evolving" insects stands in irreconcilable opposition to the *crescendo* of the "evolving" mammals, and constitutes a difficulty which a purely mechanistic philosophy can never surmount.

Not to prolong excessively this already protracted enumeration of discrepancies between fossil fact and evolutionary assumption, we shall mention, as an eighth and final difficulty, the indubitable persistence of *unchanged* organic types from the earliest geological epochs down to the present time. This phenomenon is all the more wonderful in view of the fact that the decision as to which are to be the "older" and which the "younger" strata rests with the evolutionary geologist, who is naturally disinclined to admit the antiquity of strata containing modern types, and whose position as arbiter enables him to date formations aprioristically, according to the exigencies of the transformistic theory. Using, as he does, the absence of modern types as an express criterion of age, and having, as it were, his pick among the various fossiliferous deposits, one would expect him to be eminently successful in eliminating from the stratigraphic groups selected for senior honors all strata containing fossil types identical with modern forms. Since, however, even the most ingenious sort of geological gerrymandering fails to make this elimination complete, we must conclude that the evidence for persistence of type is inescapable and valid under any assumption.

When we speak of persistent types, we mean generic and specific, rather than phyletic, types, although it is assuredly true that the persistence of the great phyla, from their abrupt and contemporaneous appearance in Cambrian and pre-Cambrian rocks down to the present day, constitutes a grave difficulty for progressive evolution in general and monophy-

letic evolution in particular. All the great invertebrate types, such as the protozoa, the annelida, the brachiopoda, and large crustaceans called eurypterids, are found in rocks of the Proterozoic group, despite the damaged condition of the Archæan record, while in the Cambrian they are represented by a great profusion of forms. "The Lower Cambrian species," says Dana, "have not the simplicity of structure that would naturally be looked for in the earliest Palæozoic life. They are perfect of their kind and highly specialized structures. No steps from simple kinds leading up to them have been discovered; no line from the protozoans up to corals, echinoderms, or worms, or from either of these groups up to brachiopods, mollusks, trilobites, or other crustaceans. This appearance of abruptness in the introduction of Cambrian life is one of the striking facts made known by geology." ("Manual," p. 487.) Thus, as we go backward in time, we find the great organic phyla retaining their identity and showing no tendency to converge towards a common origin in one or a few ancestral types. For this reason, as we shall see presently, geologists are beginning to relegate the evolutionary process to unknown depths below the explored portion of the "geological column." What may lurk in these unfathomed profundities, it is, of course, impossible to say, but, if we are to judge by that part of the column which is actually exposed to view, there is no indication whatever of a steady progression from lower, to higher, degrees of organization, and it takes all the imperturbable idealism of a scientific doctrinaire to discern in such random, abrupt, and unrelated "origins" any evidence of what Blackwelder styles "a slow but steady increase in complexity of structure and in function." (*Science*, Jan. 27, 1922, p. 90.)

But, while the permanence of phyletic types excludes progress, that of generic and specific types excludes change, and hence it is in the latter phenomenon, especially, that the theory of transformism encounters a formidable difficulty. Palæobotany furnishes numerous examples of the persistence of un-

changed plant forms. Ferns identical with the modern genus *Marattia* occur in rocks of the Palæozoic group. Cycads indistinguishable from the extant genera *Zamia* and *Cycas* are found in strata belonging to the Triassic system, etc., etc.

The same is true of animal types. In all the phyla some genera and even species have persisted unchanged from the oldest strata down to the present day. Among the Protozoa, for example, we have the genus *Globigerina* (one of the Foraminifera), some modern species of which are identical with those found in the Cretaceous. To quote the words of the Protozoologist, Charles A. Kofoid: "The Protozoa are found in the oldest fossiliferous rocks and the genera of *Radiolaria* therein conform rather closely to genera living today, while the fossil *Dinoflagellata* of the flints of Delitzsch are scarcely distinguishable from species living in the modern seas. The striking similarities of the most ancient fossil Protozoa to recent ones afford some ground for the inference that the Protozoa living today differ but little from those when life was young." (*Science,* April 6, 1923, p. 397.)

The Metazoa offer similar examples of persistence. Among the Cœlenterata, we have the genus *Springopora,* whose representatives from the Carboniferous limestones closely resemble some of the present-day reef builders of the East Indies. Species of the brachiopod genera *Lingula* and *Crania* occurring in the Cambrian rocks are indistinguishable from species living today, while two other modern genera of the Brachiopoda, namely, *Rhynchonella* and *Discina,* are represented among the fossils found in Mesozoic formations. *Terebratulina striata,* a fossil species of brachiopod occurring in the rocks belonging to the Cretaceous system, is identical with our modern species *Terebratulina caput serpentis.* Among the Mollusca such genera as *Arca, Nucula, Lucina, Astarte,* and *Nautilus* have had a continuous existence since the Silurian, while the genera *Lima* and *Pecten* can be traced to the Permian. One genus *Pleurotomaria* goes back to pre-Cambrian times. As to Tertiary fossils, Woods informs us that "in some of the later Cain-

ozoic formations as many as 90 per cent of the species of mollusks are still living." ("Palæontology," 1st ed., p. 2.) Among the Echinodermata, two genera, *Cidaris* (a sea urchin) and *Pentacrinus* (a crinoid) may be mentioned as being persistent since the Triassic ("oldest" system of the Mesozoic group). Among the Arthropoda, the horseshoe crab *Limulus polyphemus* has had a continuous existence since the Lias (*i.e.* the lowest series of the Jurassic system). Even among the Vertebrata we have instances of persistence. The extant Australian genus *Ceratodus*, a Dipnoan, has been in existence since the Triassic. Among the fossils of the Jurassic (middle system of the Mesozoic group), *Sharks, Rays,* and *Chimaeroids* occur in practically modern forms, while some of the so-called "ganoids" are extremely similar to our present sturgeons and gar pikes—"Some of the Jurassic fishes approximate the teleosts so closely that it seems arbitrary to call them ganoids." (Scott.)

The instances of persistence enumerated above are those acknowledged by evolutionary palæontologists themselves. This list could be extended somewhat by the addition of several other examples, but even so, it would still be small and insufficient to tip the scales decisively in favor of fixism. On the other hand, we must not forget that the paucity of this list is due in large measure to the fact that our present method of classifying fossiliferous strata was deliberately framed with a view to excluding formations containing modern types from the category of "ancient" beds. Moreover, orthodox palæontology has minimized the facts of persistence to an extent unwarranted even by its own premises. As the following considerations indicate, the actual number of persistent types is far greater, even according to the evolutionary time-scale, than the figure commonly assigned.

First of all, we must take into account the deplorable, if not absolutely dishonest, practice, which is in vogue, of inventing new names for the fossil duplicates of modern species, in order to mask or obscure an identity which conflicts with

evolutionary preconceptions. When a given formation fails to fit into the accepted scheme by reason of its fossil anachronisms, or when, to quote the words of Price, "species are found in kinds of rock where they are not at all expected, and where, according to the prevailing theories, it is quite incredible that they should be found . . . the not very honorable expedient is resorted to of inventing a new name, specific or even generic, to disguise and gloss over the strange similarity between them and the others which have already been assigned to wholly different formations." ("The New Geology," p. 291.) The same observation is made by Heilprin. "It is practically certain," says the latter, "that numerous forms of life, exhibiting no distinctive characters of their own, are constituted into distinct species for no other reason than that they occur in formations widely separated from those holding their nearest kin." ("Geographical and Geological Distribution of Animals," pp. 183, 184.) An instance of this practice occurs in the foregoing list, where a fossil brachiopod identical with a modern species receives the new specific name "*striata.*" Its influence is also manifest in the previously quoted apology of Scott for calling teleost-like fish "ganoids."

We must also take into account the imperfection of the fossil record, which is proved by the fact that most of the acknowledged "persistent types" listed above "skip" whole systems and even groups of "later" rocks (which are said to represent enormous intervals of time), only to reappear, at last, in modern times. It is evident that their existence has been continuous, and yet they are not represented in the intervening strata. Clearly, then, the fossil record is imperfect, and we must conclude that many of our modern types actually did exist in the remote past, without, however, leaving behind any vestige of their former presence.

Again, we must frankly confess our profound ignorance with respect to the total number and kinds of species living in our modern seas. Hence our conventional distinction between "extinct" and "extant" species has only a provisory value. Future

discoveries will unquestionably force us to admit that many of the species now classed as "extinct" are in reality living forms, which must be added to our list of "persistent types." "It is by no means improbable," says Heilprin, "that many of the older genera, now recognized as distinct by reason of our imperfect knowledge concerning their true relationships, have in reality representatives in the modern sea." (*Op. cit.* pp. 203, 204.)

Finally, the whole of our present taxonomy of plants and animals, both living and fossil, stands badly in need of revision. Systematists, as we have seen in the second chapter, base their classifications mainly on what they regard as basic or homologous structures, in contradistinction to superficial or adaptive characters. Both kinds of structure, however, are purely somatic, and somatic characters, as previously observed, are not, by themselves, a safe criterion for discriminating between varieties and species. In the light of recent genetical research, we cannot avoid recognizing that there has been far too much "splitting" of organic groups on the basis of differences that are purely fluctuational, or, at most, mutational. Moreover, the distinction between homologous and adaptive structures is often arbitrary and largely a matter of personal opinion, especially when numerous specimens are not available. What the "Cambridge Natural History" says in allusion to the Asteroidea is of general application. "While there is considerable agreement," we read, "amongst authorities as to the number of families, or minor divisions of unequivocal relationship, to be found in the class Asteroidea, there has been great uncertainty both as to the number and limits of the orders into which the class should be divided, and also as to the limits of the various species. The difficulty about the species is by no means confined to the group Echinodermata; in all cases where the attempt is made to determine species by an examination of a few specimens of unknown age there is bound to be uncertainty; the more so, as it becomes increasingly evident that there is no

sharp line to be drawn between local varieties and species. In Echinodermata, however, there is the additional difficulty that the acquisition of ripe genital cells does not necessarily mark the termination of growth; the animals can continue to grow and at the same time slightly alter their characters. For this reason many of the species described may be merely immature forms. . . .

"The disputes, however, as to the number of orders included in the Asteroidea proceed from a different cause. The attempt to construct detailed phylogenies involves the assumption that one set of structures, which we take as the mark of the class, has remained constant, whilst the others which are regarded as adaptive, may have developed twice or thrice. As the two sets of structures are about of equal importance it will be seen to what an enormous extent the personal equation enters in the determination of these questions." (*Op. cit.*, vol. I, pp. 459, 460.)

In dealing with fossil forms, these difficulties of the taxonomist are intensified: (1) by the sparse, badly-preserved, and fragmentary character of fossil remains; (2) by the fact that here breeding experiments are impossible, and hence the diagnosis based on external characters cannot be supplemented by a diagnosis of the germinal factors. Fossil taxonomy is, in consequence, extremely arbitrary and unreliable. Many fossil forms classed as distinct species, or even as distinct genera, may be nothing more than fluctuants, mutants, hybrids, or immature stages of well-known species living today. Again, many fossils mistaken for distinct species are but different stages in the life-history of a single species, a mistake, which is unavoidable, when specimens are few and the age of the specimens unknown. The great confusion engendered in the classification of the hydrozoa by nineteenth-century ignorance of the alternation of hydroid and medusoid generations is a standing example of the danger of classifying forms without a complete knowledge of the entire life-cycle. When due allowance is made for mutation, hybridization, metagenesis, polymorphism,

age and metamorphosis, the number of distinct fossil species will undergo considerable shrinkage. Nor must we overlook the possibility of environmentally-induced modifications. Many organisms, such as mollusks, undergo profound alteration as a result of some important, and, perhaps, relatively permanent, change in their environmental conditions, though such alterations affect only the phenotype, and do not involve a corresponding change in the specific genotype, *i.e.* the germinal constitution of the race.

In the degree that these considerations are taken into account the number of "extinct" fossil species will diminish and the number of "persistent" species will increase. This is a consummation devoutly to be wished for, but it means that hundreds of thousands of described species must needs be reviewed for the purpose of weeding out the duplicates, and who will have the knowledge, the courage, or even the span of life, necessary to accomplish so gigantic a task?

But so far as the practical purposes of our argument are concerned, the accepted list of persistent types needs no amplification. It suffices, as it stands, to establish the central fact (which, for the rest, is admitted by everyone) that some generic and even specific types have remained unchanged throughout the enormous lapse of time which has intervened between the deposition of the oldest strata and the advent of the present age. Our current theories, far from diminishing the significance of this fact, tend to intensify it by computing the duration of such persistence in millions, rather than in thousands, of years. Now, whatever one's views may be on the subject of transformism, this prolonged permanence of certain genera and species is an indubitable *fact*, which is utterly irreconcilable with a *universal law* of organic evolution. The theory of transformism is impotent to explain an exception so palpable as this; for persistence and transmutation cannot be subsumed under one and the same principle. That which accounts for change cannot account for *unchange*. Yet unchange is an observed fact, while the change, in this case, is an inferred

hypothesis. Hence, even if we accept the principle of transformism, there will always be scope for the principle of permanence. The extraordinary tenacity of type manifested by persistent genera and species is a phenomenon deserving of far more careful study and investigation than the evolutionally-minded scientist of to-day deigns to bestow upon it. To the latter it may seem of little consequence, but, to the genuine scientist, the actual persistence of types should be of no less interest than their possible variability.

With these reflections, our criticism of the palæontological argument terminates. The enumeration of its various deficiencies was not intended as a refutation. To disprove the theory of organic evolution is a feat beyond our power to accomplish. We can only adduce negative evidence, whose scope is to show that the various evolutionary arguments are inconsequential or inconclusive. We cannot rob the theory of its intrinsic possibility, and sheer justice compels us to confess that certain facts, like those of symbiotic preadaptation, lend themselves more readily to a transformistic, than to a fixistic, interpretation. On the other hand, nothing is gained by ignoring flaws so obvious and glaring as those which mar the cogency of palæontological "evidence." The man who would gloss them over is no true friend either of Science or of the scientific theory of Evolution! They represent so many real problems to be frankly faced and fully solved, before the palæontological argument can become a genuine demonstration. But until such time as a demonstration of this sort is forthcoming, the evolutionist must not presume to cram his unsubstantiated theory down our reasonably reluctant throats. To accept as certain what remains unproved, is to compromise our intellectual sincerity. True certainty, which rests on the recognition of objective necessity, will never be attainable so long as difficulties that sap the very base of evolutionary argumentation are left unanswered; and, as for those who, in the teeth of discordant factual evidence, profess, nevertheless, to have certainty regarding the "fact" of evolution, we can

only say that such persons cannot have a very high or exacting conception of what scientific certainty really means.

For the rest, it cannot even be said that the palæontological record furnishes good circumstantial evidence that our globe has been the scene of a process of organic evolution. In fact, so utterly at variance with this view is the total impression conveyed by the visible portion of the geological column, that the modern geologist proposes, as we have seen, to probe depths beneath its lowest strata for traces of that alleged transmutation, which higher horizons do not reveal. There are six to eight thick terranes below the Cambrian, we are told, and igneous masses that were formerly supposed to be basal have turned out to be intrusions into sedimentary accumulations, all of which, of course, is fortunate for the theory of organic evolution, as furnishing it with a sadly needed new court of appeal. The bottom, so to speak, has dropped out of the geological column, and Prof. T. C. Chamberlin announces the fact as follows: "The sharp division into two parts, a lifeless igneous base and a sedimentary fossiliferous superstructure, has given place to the general concept of continuity with merely minor oscillations in times and regions of major activity. Life has been traced much below the Cambrian, but its record is very imperfect. The recent discoveries of more ample and varied life in the lower Palæozoic, particularly the Cambrian, implies, under current evolutional philosophy, a very great downward extension of life. In the judgment of some biologists and geologists, this extension probably reaches below all the pre-Cambrian terranes as yet recognized, though this pre-Cambrian extension is great. The 'Azoic' bottom has retired to depths unknown. This profoundly changes the life aspect of the 'column.' " (*Science*, Feb. 8, 1924, p. 128.) All this is doubtless true, but such an appeal, from the known to the unknown, from the actual to the possible, is not far-removed from a confession of scientific insolvency. Life must, of course, have had an earlier history than that recorded in the pre-Cambrian rocks. But even supposing that some portion of an

earlier record should become accessible to us, it could not be expected to throw much light on the problem of organic origins. Most of the primordial sediments have long since been sapped and engulfed by fiery magmas, while terranes less deep have, in all probability, been so metamorphosed that every trace of their fossil contents has perished. The sub-Archæan beginnings of life will thus remain shrouded forever in a mystery, which we have no prospect of penetrating. Hence it is the exposed portion of the geological column which continues and will continue to be our sole source of information, and it is preëminently on this basis that the evolutionary issue will have to be decided.

Yet what could be more enigmatic than the rock record as it stands? For in nature it possesses none of that idealized integrity and coherence, with which geology has invested it for the purpose of making it understandable. Rather it is a mighty chaos of scattered and fragmentary fossiliferous formations, whose baffling complexity, discontinuity, and ambiguity tax the ingenuity of the most sagacious interpreters. Transformism is the key to one possible synthesis, which might serve to unify that intricate mass of facts, but it is idle to pretend that this theory is the unique and necessary corollary of the facts as we find them. The palæontological argument is simply a theoretical construction which presupposes evolution instead of proving it. Its classic pedigrees of the horse, the camel, and the elephant are only credible when we have assumed the "fact" of evolution, and even then, solely upon condition that they claim to approximate, rather than assign, the actual ancestry of the animals in question. In palæontology, as in the field of zoölogy, evolution is not a conclusion, but an interpretation. In palæontology, otherwise than in the field of genetics, evolution is not amenable to the check of experimental tests, because here it deals not with that which *is*, but with that which *was*. Here the sole objective basis is the mutilated and partially obliterated record of a march of events, which no one has observed and which will never be repeated.

These obscure and fragmentary vestiges of a vanished past, by reason of their very incompleteness, lend themselves quite readily to all sorts of theories and all sorts of speculations. Of the "Stone Book of the Universe" we may say with truth that which Oliver Wendell Holmes says of the privately-interpreted Bible, namely, that its readers take from it the same views which they had previously brought to it. "I am, however, thoroughly persuaded," say the late Yves Delage, "that one is or is not a transformist, not so much for reasons deduced from natural history, as for motives based on personal philosophic opinions. If there existed some other scientific hypothesis besides that of descent to explain the origin of species, many transformists would abandon their present opinion as not being sufficiently demonstrated. . . . If one takes his stand upon the exclusive ground of the facts, it must be acknowledged that the formation of one species from another species has not been demonstrated at all." ("L'herédité et les grands problèmes de la biologie générale," Paris, 1903, pp. 204, 322.)

PART II

THE PROBLEM OF ORIGINS

II

THE PROBLEM OF ORIGINS

CHAPTER I

THE ORIGIN OF LIFE

§ 1. The Theory of Spontaneous Generation

Strictly speaking, the theory of Transformism is not concerned with the initial production of organic species, but rather with the subsequent differentiation and multiplication of such species by transmutation of the original forms. This technical sense, however, is embalmed only in the term transformism and not in its synonym evolution. The signification of the latter term is less definite. It may be used to denote any sort of development or origination of one thing from another. Hence the problem of the formation of organic species is frequently merged with the problem of the transformation of species under the common title of evolution.

This extension of the evolutionary concept, in its widest sense, to the problem of the origin of life on our globe is known as the hypothesis of abiogenesis or spontaneous generation. It regards inorganic matter as the source of organic life not merely in the sense of a *passive cause*, out of which the primordial forms of life were produced, but in the sense of an *active cause* inasmuch as it ascribes the origin of life to the exclusive agency of dynamic principles inherent in inorganic matter, namely, the physicochemical energies that are native to mineral matter. Life, in other words, is assumed to have arisen spontaneously, that is, by means of a synthesis

and convergence of forces resident in inorganic matter, and not through the intervention of any exterior agency.

The protagonists of spontaneous generation, therefore, assert not merely a passive, but an active, evolution of living, from lifeless matter. As to the fact of the origin of the primal organisms from inorganic matter, there is no controversy whatever. All agree that, at some time or other, the primordial plants and animals emanated from inorganic matter. The sole point of dispute is whether they arose from inorganic matter by active evolution or simply by passive evolution. The passive evolution of mineral matter into plants and animals is an everyday occurrence. The grass assimilates the nitrates of the soil, and is, in turn, assimilated by the sheep, whose flesh becomes the food of man, and mineral substance is thus finally transformed into human substance. In the course of metabolic processes, the inorganic molecule may doff its mineral type and don, in succession, the specificities of plant, animal, and human protoplasm; and this transition from lower to higher degrees of perfection may be termed an evolution. It is an ascent of matter from the lowermost grade of an inert substance, through the intermediate grades of vegetative and animal life, up to the culminating and ultimate term of material perfection, in the partial constitution of a human nature and personality, in the concurrence as a coagent in vegetative and sensile functions, and in the indirect participation, as instrument, in the higher psychic functions of rational thought and volition.

At the present time, the inorganic world is clearly the exclusive source of all the matter found in living beings. All living beings construct their bodies out of inorganic substances in the process of nutrition, and render back to the inorganic world, by dissimilation and death, whatever they have taken from it. We must conclude, therefore, the matter of the primordial organisms was likewise derived from the inorganic world. But we are not warranted in concluding that this process of derivation was an active evolution. On the

contrary, all evidence is against the supposition that brute matter is able to evolve of itself into living matter. It can, indeed, be transformed into plants, animals, and men through the action of an appropriate external agent (*i.e.* solely through the agency of the living organism), but it cannot acquire the perfections of living matter by means of its own inherent powers. It cannot vitalize, or sensitize, itself through the unaided activity of its own physicochemical energies. Only when it comes under the superior influence of preëxistent life can it ascend to higher degrees of entitive perfection. It does not become of itself life, sensibility, and intelligence. It must first be drawn into communion with what is already alive, before it can acquire life and sensibility, or share indirectly in the honors of intelligence (as the substrate of the cerebral imagery whence the human mind abstracts its conceptual thought). Apart from this unique influence, inorganic matter is impotent to raise itself in the scale of existence, but, if captured, molded, and transmuted by a living being, it may progress to the point of forming with the human soul one single nature, one single substance, one single person. The evolution of matter exemplified in organic metabolism is obviously passive, and such an evolution of the primal organisms out of non-living matter even the opponents of the hypothesis of spontaneous generation concede. But spontaneous generation implies an active evolution of the living from the lifeless, and this is the point around which the controversy wages. It would, of course, be utterly irrational to deny to the Supreme Lord and Author of Life the power of vivifying matter previously inanimate and inert, and hence the origin of organic life from inorganic matter by a formative (not creative) act of the Creator is the conclusion to which the denial of abiogenesis logically leads.

The hypothesis of spontaneous generation is far older than the theory of transformism. It goes back to the Greek predecessors of Aristotle, at least, and may be of far greater antiquity. It was based, as is well known, upon an erroneous

interpretation of natural facts, which was universally accepted up to the close of the 17th century. As we can do no more than recount a few outstanding incidents of its long and interesting history here, the reader is referred to the VII chapter of Wasmann's "Modern Biology" and the VIII chapter of Windle's "Vitalism and Scholasticism" for the details which we are obliged to omit.

§ 2. The Law of Genetic Continuity

From time immemorial the sudden appearance of maggots in putrescent meat had been a matter of common knowledge, and the ancients were misled into regarding the phenomenon as an instance of a *de novo* origin of life from dead matter. The error in question persisted until the year 1698, when it was decisively disproved by a simple experiment of the Italian physician Francesco Redi. He protected the meat from flies by means of gauze. Under these conditions, no maggots appeared in the meat, while the flies, unable to reach the meat, deposited their eggs on the gauze. Thus it became apparent that the maggots were larval flies, which emerged from fertilized eggs previously deposited in decaying meat by female flies. Antonio Vallisnieri, another Italian, showed that the fruit-fly had a similar life-history. As a result of these discoveries, Redi rejected the theory of spontaneous generation and formulated the first article of the Law of Genetic Vital Continuity: *Omne vivum ex vivo.*

Meanwhile, the first researches conducted by means of the newly invented compound microscope disclosed what appeared to be fresh evidence in favor of the discarded hypothesis. The unicellular organisms known as infusoria were found to appear suddenly in hay infusions, and their abrupt appearance was ascribed to spontaneous generation. Towards the end of the 18th century, however, a Catholic priest named Lazzaro Spallanzani refuted this new argument by sterilizing the infusions with heat and by sealing the containers as protection against contamination by floating spores or cysts. After the

infusions had been boiled for a sufficient time and then sealed, no organisms could be found in them, no matter how long they were kept. We now know that protozoa and protophytes do not originate *de novo* in infusions. Their sudden appearance in cultures is due to the deposition of spores or cysts from the air, etc.

The possibility that the non-germination of life in sterilized infusions kept in sealed containers might be due to the absence of oxygen, removed by boiling and excluded by sealing, left open a single loophole, of which the 19th century defenders of abiogenesis proceeded to avail themselves. Pasteur, however, by employing sterilized cultures, which he aerated with filtered air exclusively, succeeded in depriving his opponents of this final refuge, and thereby completely demolished the last piece of evidence in favor of spontaneous generation. Prof. Wm. Sydney Thayer, in an address delivered at the Sorbonne, May 22, 1923, gives the following account of Pasteur's experiments in this field: "Then, naturally (1860-1876) came the famous studies on spontaneous generation undertaken against the advice of his doubting masters, Biot and Dumas. On the basis of careful and well-conceived experiments he demonstrated the universal presence of bacteria in air, water, dust; he showed the variation in different regions of the bacterial content of the air; he demonstrated the permanent sterility of media protected from contamination, and he insisted on the inevitable derivation of every living organism from one of its kind. 'No,' he said, 'there is no circumstance known today which justifies us in affirming that microscopic organisms have come into the world, without parents like themselves. Those who made this assertion have been the playthings of illusions or ill-made experiments invalidated by errors which they have not been able to appreciate or to avoid.' In the course of these experiments he demonstrated the necessity of reliable methods of sterilization for instruments or culture media, of exposure for half an hour to moist heat at 120° or to dry air at 180°. And behold! our modern

procedures of sterilization and the basis of antiseptic surgery." (*Science*, Dec. 14, 1923, p. 477.) Pasteur brought to a successful completion the work of Redi and Spallanzani. Henceforth spontaneous generation was deprived of all countenance in the realm of biological fact.

Meanwhile, the cytologists and embryologists of the last century were adding article after article to the law of genetic cellular continuity, thus forging link by link the fatal chain of severance that inexorably debars abiogenesis from the domain of natural science. With the formulation of the great Cell Theory by Schleiden and Schwann (1838-1839), it became clear that the cell is the fundamental unit of organization in the world of living matter. It has proved to be, at once, the simplest organism capable of independent existence and the basic unit of structure and function in all the more complex forms of life. The protists (unicellular protozoans and protophytes) consist each of a single cell, and no simpler type of organism is known to science. The cell is the building brick out of which the higher organisms or metists (*i.e.* the multicellular and tissued metazoans and metaphytes) are constructed, and all multicellular organisms are, at one time or other in their career, reduced to the simplicity of a single cell (*v.g.* in the zygote and spore stages). The somatic or tissue cells, which are associated in the metists to form one organic whole, are of the same essential type as germ cells and unicellular organisms, although the parallelism is more close between the unicellular organism and the germ cell. The germ cell, like the protist, is equipped with all the potentialities of life, whereas tissue cells are specialized for one function rather than another. The protist is a generalized and physiologically-balanced cell, one which performs all the vital functions, and in which the suppression of one function leads to the destruction of all the rest; while the tissue cell is a specialized and physiologically-unbalanced cell limited to a single function, with the other vital functions in abeyance (though capable of manifesting themselves under certain cir-

cumstances). Normally, therefore, the tissue cell is functionally incomplete, a part and not a whole, whereas the protist is an independent individual, being, at once, the highest type of cell and the lowest type of organism.

According to the classic definition of Franz Leydig and Max Schultze, the cell is a mass of protoplasm containing a nucleus, both protoplasm and nucleus arising through division of the corresponding elements of a preëxistent cell. In this form the definition is quite general and applies to all cells, whether tissue cells, germ cells, or unicellular organisms. Moreover, it embodies two principles which still further determine the law of genetic cellular continuity, namely: *Omnis cellula ex cellula*, enunciated by Virchow in 1855, and Flemming's principle: *Omnis nucleus ex nucleo*, proclaimed in 1882. In this way, Cytology supplemented Redi's formula that every living being is from a preëxistent living being, by adding two more articles, namely, that every living cell is from a preëxistent cell, and every new cellular nucleus is derived by division from a preëxistent cellular nucleus. Now neither the nucleus nor the cell-body (the cytoplasm or extranuclear area of the cell) is capable of an independent existence. The cytoplasm of the severed nerve fibre, when it fails to reëstablish its connection with the neuron nucleus, degenerates. The enucleated amœba, though capable of such vital functions as depend upon destructive metabolism, can do nothing which involves constructive metabolism, and is, therefore, doomed to perish. The sperm cell, which is a nucleus that has sloughed off most of its cytoplasm, disintegrates, unless it regains a haven in the cytoplasm of the egg. Life, accordingly, cannot subsist in a unit more simply organized than the cell. No organism lives which is simpler than the cell, and the origin of all higher forms of life is reducible, as we shall see, to the origin of the cell. Consequently, new life can originate in no other way than by a process of cell-division. All generation or reproduction of new life is dependent upon the division of the cell-body and nucleus of a preëxistent living cell.

Haeckel, it is true, has attempted to question the status of the cell as the simplest of organisms, by alleging the existence of cytodes (non-nucleated cells) among the bacteria and the blue-green algæ. Further study, however, has shown that bacteria and blue-green algæ have a distributed nucleus, like that of certain ciliates, such as *Dileptus gigas* and *Trachelocerca.* In such forms the entire cell body is filled with scattered granules of chromatin called chromioles, and this diffuse type of nucleus seems to be the counterpart of the concentrated nuclei found in the generality of cells. At any rate, there is a temporary aggregation of the chromioles at critical stages in the life-cycle (such as cell-division), and these scattered chromatin granules undergo division, although their distribution to the daughter-cells is not as regular as that obtaining in mitosis. All this is strongly suggestive of their nuclear nature, and cells with distributed nuclei cannot, therefore, be classified as cytodes. In fact, the polynuclear condition is by no means uncommon. *Paramœcium aurelia,* for example, has a macronucleus and a micronucleus, and the *Uroleptus mobilis* has eight macronuclei and from two to four micronuclei. The difference between the polynuclear and diffuse condition seems to be relatively unimportant. In fact, the distributed nucleus differs from the morphological nucleus mainly in the absence of a confining membrane. From the functional standpoint, the two structures are identical. Hence the possession of a nucleus or its equivalent is, to all appearances, a universal characteristic of cells. Haeckel's "cytodes" have proved to be purely imaginary entities. The verdict of modern cytologists is that Shultze's definition of the cell must stand, and that the status of the cell as the simplest of organic units capable of independent existence is established beyond the possibility of prudent doubt.

With the progressive refinement of microscopic technique, it has become apparent that the law of genetic continuity applies not merely to the cell as a whole and to its major parts, the nucleus and the cell-body, but also to the minor com-

ponents or organelles, which are seen to be individually self-perpetuating by means of growth and division. The typical cell nucleus, as is well known, is a spherical vesicle containing a semisolid, diphasic network of basichromatin (formerly "chromatin") and oxychromatin (linin) suspended in more fluid medium or ground called nuclear sap. When the cell is about to divide, the basichromatin resolves itself into a definite number of short threads called chromosomes. Now, Boveri found that, in the normal process of cell-division known as mitosis, these nuclear threads or chromosomes are each split lengthwise and divided into two exactly equivalent halves, the resulting halves being distributed in equal number to the two daughter-cells produced by the division of the original cell. Hence, in the year 1903, Boveri added a fourth article to the law of genetic vital continuity, namely: *Omne chromosoma ex chromosomate.*

But the law in question applies to cytoplasmic as well as nuclear components. In physical appearance, the cell-body or cytoplasm resembles an emulsion with a clear semiliquid external phase called hyaloplasm and an internal phase consisting mainly of large spheres called macrosomes and minute particles called microsomes, all of which, together with numerous other formed bodies, are suspended in the clear hyaloplasm (hyaline ground-substance). Now certain of these cytoplasmic components have long been known to be *self-perpetuating* by means of growth and division, maintaining their continuity from cell to cell. The plastids of plant cells, for example, divide at the time of cell-division, although their distribution to the daughter-cells does not appear to be as definite and regular as that which obtains in the case of the chromosomes. Similarly, the centrioles or division-foci of animal cells are self-propagating by division, but here the distribution to the daughter-cells is exactly equivalent and not at random as in the case of plastids. In the light of recent research it looks as though two other types of cytoplasmic organelles must be added to the list of cellular

components, which are individually self-perpetuating by growth and division, namely, the chondriosomes and the Golgi bodies—"both mitochondria and Golgi bodies are able to assimilate, grow, and divide in the cytoplasm." (Gatenby.) Wilson is of opinion that the law of genetic continuity may have to be extended even to those minute granules and particles of the cytosome, which were formerly thought to arise *de novo* in the apparently structureless hyaloplasm. Speaking of the emulsified appearance of the starfish and sea urchin eggs, he tells us that their protoplasm shows "a structure somewhat like that of an emulsion, consisting of innumerable spheroidal bodies suspended in a clear continuous basis or hyaloplasm. These bodies are of two general orders of magnitude, namely: larger spheres or macrosomes rather closely crowded and fairly uniform in size, and much smaller microsomes irregularly scattered between the macrosomes, and among these are still smaller granules that graduate in size down to the limit of vision with any power (*i.e.* of microscope) we may employ." (*Science*, March 9, 1923, p. 282.) Now, the limit of microscopic vision by the use of the highest-power oil-immersion objectives is one-half the length of the shortest waves of visible light, that is, about 200 submicrons (the submicron being one millionth of a millimeter). Particles whose diameter is less than this cannot reflect a wave of light, and are, therefore, invisible so far as the microscope is concerned. By the aid of the ultramicroscope, however, we are enabled to see the halos formed by particles not more than four submicrons in diameter, which, however, represents the limit of the ultramicroscope, and is the diameter hypothetically assigned to the protein multimolecule. Since, therefore, we find the particles in the protoplasm of the cell body graduating all the way down to the limit of this latter instrument, and since on the very limit of microscopic vision we find such minute particles as the centrioles "capable of self-perpetuation by growth and division, and of enlargement to form much larger bodies," we cannot ignore the possibility

that the ultramicroscopic particles may have the same powers and may be the sources or "formative foci" of the larger formed bodies, which were hitherto thought to arise *de novo*.

Certainly, pathology, as we shall see, tells us of ultramicroscopic disease-germs, which are capable of reproduction and maintenance of a specific type, and experimental genetics makes us aware of a linear alignment of submicroscopic genes in the nuclear chromosomes, each gene undergoing periodic division and perpetual transmission from generation to generation. The cytologist, therefore, to quote the words of Wilson, "cannot resist the evidence that the appearance of a simple homogeneous colloidal substance is deceptive; that it is in reality a complex, heterogeneous, or polyphasic system. He finds it difficult to escape the conclusion, therefore, that the visible and the invisible components of the protoplasmic system differ only in their size and degree of dispersion; that they belong to a single continuous series, and that the visible structure of protoplasm may give us a rough magnified picture of the invisible." (*Ibidem*, p. 283.)

It would seem, therefore, that we must restore to honor, as the fifth article of the law of cellular continuity, the formula, which Richard Altmann enunciated on purely speculative grounds in 1892, but which the latest research is beginning to place on a solid factual basis, namely: *Omne granulum ex granulo*. "For my part," says the great cytologist, Wilson, "I am disposed to accept the probability that many of these particles, as if they were submicroscopical plastids, may have a persistent identity, perpetuating themselves by growth and multiplication without loss of their specific individual type." And he adds that the facts revealed by experimental embryology (*e.g.*, the existence of differentiated zones of specific composition in the cytoplasm of certain eggs) "drive us to the conclusion that the submicroscopical components of the hyaloplasm are segregated and distributed according to an ordered system." (*Ibidem*, p. 283.) The structure of the cell has often been likened to a heterogeneous solution,

that is, to a complex polyphasic colloidal system, but this power of perpetual division and orderly assortment possessed by the cell as a whole and by its single components is the unique property of the living protoplasmic system, and is never found in any of the colloidal systems known to physical chemistry, be they organic or inorganic.

Cells, then, originate solely by division of preëxistent cells and even the minor components of the cellular system originate in like fashion, namely: by division of their respective counterparts in the preëxistent living cell. Here we have the sum and substance of the fivefold law of genetic continuity, whose promulgation has relegated the hypothesis of spontaneous generation to the realms of empty speculation. Waiving the possibility of an *a priori* argument, by which abiogenesis might be positively excluded, there remains this one consideration, which alone is scientifically significant, that, so far as observation goes and induction can carry us, the living cell has absolute need of a vital origin and can never originate by the exclusive agency of the physico-chemical forces native to inorganic matter. If organic life exists in simpler terms than the cell, science knows nothing of it, and no observed process, simple or complicated, of inorganic nature, nor any artificial synthesis of the laboratory, however ingenious, has ever succeeded in duplicating the wonders of the simplest living cell.

§ 3. Chemical Theories of the Origin of Life

In fact, the very notion of a chemical synthesis of living matter is founded on a misconception. It would, indeed, be rash to set limits to the chemist's power of synthesizing organic compounds, but living protoplasm is not a single chemical compound. Rather it is a complex system of compounds, enzymes and organelles, coördinated and integrated into an organized whole by a persistent principle of unity and finality. Organic life, to say nothing at all of its unique dynamics, is a morphological as well as a chemical problem;

and, while it is conceivable that the chemist might synthesize all the compounds found in dead protoplasm, to reproduce a single detail of the ultramicroscopic structure of a living cell lies wholly beyond his power and province. "Long ago," says Wilson (in the already quoted address on the "Physical Basis of Life"), "it became perfectly plain that what we call protoplasm is not chemically a single substance. It is a mixture of many substances, a mixture in high degree complex, the seat of varied and incessant transformations, yet one which somehow holds fast for countless generations to its own specific type. The evidence from every source demonstrates that the cell is a complex organism, a microcosm, a living system." (*Science*, March 9, 1923, p. 278.)

With the chemist, analysis must precede synthesis, and it is only after a structural formula has been determined by means of quantitative analysis supplemented by analogy and comparison, that a given compound can be successfully synthesized. But living protoplasm and its structures elude such analysis. Intravitous staining is inadequate even as a means of qualitative analysis, and tests of a more drastic nature destroy the life and organization, which they seek to analyze. "With one span," says Amé Pictet, Professor of Chemistry at the University of Geneva, "we will now bridge the entire distance separating the first products of plant assimilation from its final product, namely, living matter. And it should be understood at the outset that I employ this term 'living matter' only as an abbreviation, and to avoid long circumlocution. You should not, in reality, attribute life to matter itself; it has not, it cannot have both living molecules and dead molecules. Life requires an organization, which is that of cellular structure, but it remains, in contradistinction to it, outside the domain of strict chemistry. It is none the less true that the content of a living cell must differ in its chemical nature from the content of a dead cell. It is entirely from this point of view that the phenomenon of life pertains to my subject. . . . A living

cell, both in its chemical composition and in its morphological structure, is an organism of extraordinary complexity. The protoplasm that it incloses is a mixture of very diverse substances. But if there be set aside on the one hand those substances which are in the process of assimilation and on the other those which are the by-products of nutrition, and which are in the process of elimination, there remain the protein or albuminous substances, and these must be considered, if not the essential factor of life, at least the theater of its manifestations. . . . Chemistry, however, is totally ignorant, or nearly so, of the constitution of living albumen, for chemical methods of investigation at the very outset kill the living cell. The slightest rise in temperature, contact with the solvent, the very powerful effect of even the mildest reactions cause the transformation that needs to be prevented, and the chemist has nothing left but dead albumen." (Smithson. Inst. Rpt. for 1916, pp. 208, 209.)

Chemical analysis associated with physical analysis by means of the polariscope, spectroscope, x-rays, ultramicroscope, etc. is extremely useful in determining the structure of inorganic units like the atom and the molecule. Both, too, throw valuable light on the problem of the structure of non-living multimolecules such as the crystal units of crystalloids and the ultramicrons of colloids, but they furnish no clue to the submicroscopical morphology of the living cell. Such methods do not enable us to examine anything more than the "physical substrate" of life, and that, only after it has been radically altered; for it is not the same after life has flown. At all events, the integrating principle, the formative determinant, which binds the components of living protoplasm into a unitary system, which makes of them a single totality instead of a mere sum or fortuitous aggregate of disparate and uncoördinated factors, and which gives to them a determinate and persistent specificity that can hold its own amid a perpetual fluxion of matter and continual flow of energy, this is forever inaccessible to the chemist, and con-

stitutes a phenomenon of which the inorganic world affords no parallel.

With these facts in mind, we can hardly fail to be amused whenever certain simple chemical reactions obtained *in vitro* are hailed as "clue to the origin of life." When it was found, for instance, that, under certain conditions, an aldehyde (probably formaldehyde) is formed in a colloidal solution of chlorophyll in water, if exposed to sunlight, the discovery gave rise to Bach's formaldehyde-hypothesis; for Alexis Bach saw in this reaction "a first step in the origin of life." As formaldehyde readily undergoes aldol condensation into a syrupy fluid called formose, when a dilute aqueous solution of formaldehyde is saturated with calcium hydroxide and allowed to stand for several days, there was no difficulty in conceiving the transition from formaldehyde to the carbohydrates; for formose is a mixture containing several hexose sugars, and Fischer has succeeded in isolating therefrom acrose, a simple sugar having the same formula as glucose, namely: $C_6H_{12}O_6$. Glyceraldehyde undergoes a similar condensation. In view of these facts, carbohydrate-production in green plants was interpreted as a photosynthesis of these substances from water and carbon dioxide, with chlorophyll acting a sensitizer to absorb the radiant energy necessary for the reaction. The first step in the process was thought to be a reduction of carbonic acid to formic acid and then to formaldehyde, the latter being at once condensed into glucose, which in turn was supposed to be dehydrated and polymerized into starch. From the carbohydrates thus formed and the nitrates of the soil the plant could then synthesize proteins, while oxidation of the carbohydrates into fatty acids would lead to the formation of fats. Hence Bach regarded the formation of formaldehyde in the presence of water, carbon dioxide, chlorophyll, and sunlight as the "first step in the production of life." Bateson, however, does not find the suggestion a very helpful one, and evaluates it at its true worth in the following contemptuous aside: "We should be greatly helped," he says,

"by some indication as to whether the origin of life has been single or multiple. Modern opinion is, perhaps, inclined to the multiple theory, but we have no real evidence. Indeed, the problem still stands outside the range of scientific investigation, and when we hear the spontaneous formation of formaldehyde mentioned as a possible first step in the origin of life, we think of Harry Lauder in the character of a Glasgow schoolboy pulling out his treasures from his pocket —"That's a wassher—for makkin' motor cars." ("Presidential Address," cf. Smithson. Inst. Rpt. for 1915, p. 375.)

Bach, moreover, takes it for granted that the formation of formaldehyde is really the first step in the synthesis performed by the green plant, and he claims that formaldehyde is formed when carbon dioxide is passed through a solution of a salt of uranium in the presence of sunlight. Fenton makes a similar claim in the case of magnesium, asserting that traces of formaldehyde are discernible when metallic magnesium is immersed in water saturated with carbon dioxide. But at present it begins to look as though the spontaneous formation and condensation of formaldehyde had nothing to do with the process that actually occurs in green plants. Certain chemists, while admitting that an aldehyde is formed when chlorophyll, water, and air are brought together in the presence of sunlight, deny that the aldehyde in question is formaldehyde, and they also draw attention to the fact that this aldehyde may be formed in an atmosphere entirely destitute of carbon dioxide. In fact, the researches conducted by Willstätter and Stoll, and later (in 1916) by Jörgensen and Kidd tend to discredit the common notion that carbohydrate-production in plants is the result of a direct union of water and carbon dioxide. Botany textbooks still continue to parrot the traditional view. We cannot any longer, however, be sure but that the term photosynthesis may be a misnomer.

Carbohydrate-formation in plants seems to be more analogous to carbohydrate-formation in animals than was for-

merly thought to be the case. In animals, as is well known, glycogen or animal starch is formed not by direct synthesis, but by deämination and reduction of proteins. In a similar way, it is thought that the production of carbohydrates in plants may be due to a breaking down of the phytyl ester in chlorophyll, the chromogen group functioning (under the action of light) alternately as a dissociating enzyme in the formation of sugars and a synthesizing enzyme in the reconstruction of chlorophyll. Phytol is an unsaturated alcohol obtained when chlorophyll is saponified by means of caustic alkalis. Its formula is $C_{20}H_{39}OH$, and chlorophyll consists of a chromogen group containing magnesium ($MgN_4C_{32}H_{30}O$) united to a diester of phytyl and methyl alcohols.

Experimental results are at variance with the theory that chlorophyll acts as a sensitizer in bringing about a reduction of carbonic acid, after the analogy of eosin, which in the presence of light accelerates the decomposition of silver salts on photographic plates. Willstätter found that, when a colloidal solution of the pure extract of chlorophyll in water is exposed to sunlight and an atmosphere consisting of carbon dioxide exclusively, no formaldehyde is formed, but the chlorophyll is changed into yellow phæophytin owing to the removal of the magnesium from the chromogen group by the action of the carbonic acid. Jörgensen, on the other hand, discovered that in an atmosphere of pure oxygen, formaldehyde is formed, apparently by the splitting off and reduction of the phytyl ester of chlorophyll. Soon, however, the formaldehyde is oxidized to formic acid, which replaces the chlorophyllic magnesium with hydrogen, thus causing the green chlorophyll to degenerate into yellow phæophytin and finally to lose its color altogether. The dissociation of the chromogen group may be due to the fact that the reaction takes place *in vitro,* and may not occur in the living plant. At all events, it would seem that plants, like animals, manufacture carbohydrates by a destructive rather than a constructive process, and that water and carbon dioxide serve

rather as materials for the regeneration of chlorophyll than as materials out of which sugars are directly synthesized.

A new theory has been proposed by Dr. Oskar Baudisch, who seems to have sensed the irrelevance of the formaldehyde hypothesis, and to have sought another solution in connection with the chromogen group of chlorophyll. He finds a more promising starting-point in formaldoxime, which, he claims, readily unites with such metals as magnesium and iron and with formaldehyde, in the presence of light containing ultra-violet rays, to form organic compounds analogous to the chromogen complexes in chlorophyll and hæmoglobin. Oximes are compounds formed by the condensation of one molecule of an aldehyde with one molecule of hydroxylamine (NH_2OH) and the elimination of a molecule of water. Hence Dr. Baudisch imagines that, given formaldoxime ($H_2C{:}N{\cdot}OH$), magnesium, and ultra-violet rays, we might expect a spontaneous formation of chlorophyll leading eventually to the production of organic life. "It is his theory that life may have been caused through the direct action of sunlight upon water, air, and carbon dioxide in the ancient geologic past when, he believes, sunlight was more intense and contained more ultra-violet light and the air contained more water vapor and carbon dioxide than at the present time." (*Science*, April 6, 1923, Supplement XII.)

This is the old Spencerian evasion, the fatuous appeal to "conditions unlike those we know," the unverified and unverifiable assumption that an unknown past must have been more favorable to spontaneous generation than the known present. In archæozoic times, the temperature was higher, the partial pressure of atmospheric carbon dioxide greater, the percentage of ultra-violet rays in sunlight larger. Such contentions are interesting, if true, but, for all that, they may, "like the flowers that bloom in the spring," have nothing to do with the case. Nature does not, and the laboratory cannot, reproduce the conditions which are said to have brought about the spontaneous generation of formaldoxime and its pro-

gressive transmutation into phycocyanin, chlorophyll and the blue-green algæ. What value, then, have these conjectures? If it be the function of natural science to discount actualities in favor of possibilities, to draw arguments from ignorance, and to accept the absence of disproof as a substitute for demonstration, then the expedient of invoking the unknown in support of a speculation is scientifically legitimate. But, if the methods of science are observation and induction, if it proceeds according to the principle of the uniformity of nature, and does not utterly belie its claim of resting upon factual realities rather than the figments of fancy, then all this hypothecation, which is so flagrantly at variance with the actual data of experience and the unmistakable trend of inductive reasoning, is not science at all, but sheer credulity and superstition.

When we ask by what right men of science presume to lift the veil of mystery from a remote past, which no one has observed, we are told that the justification of this procedure is the principle of the uniformity of nature or the invariability of natural laws. Nature's laws are the same yesterday, to-day, and forever. Hence the scientist, who wishes to penetrate into the unknown past, has only to "prolong the methods of nature from the present into the past." (Tyndall.) If we reject the soundness of this principle, we automatically cut ourselves off from all certainty regarding that part of the world's history which antecedes human observation. Either nature's laws change, or they do not. If they never change, then Spontaneous Generation is quite as much excluded from the past as it is from the present. If, however, as Hamann and Fechner explicitly maintain, nature's laws do change, then, obviously, no knowledge whatever is possible respecting the past, since it is solely upon the assumption of the immutable constancy of such laws that we can venture to reconstruct prehistory.

The puerile notion that the synthesis of organic substances in the laboratory furnishes a clue to the origin of organic

life on earth is due to a confusion of organic, with living and organized, substances. It is only in the production of organic substances that the chemist can vie with the plant or animal. These are lifeless and unorganized carbon compounds, which are termed organic because they are elaborated by living organisms as a metaplastic by-product of their metabolism. Such substances, however, are not to be confounded with animate matter, *e.g.* a living cell and its organelles, or even with organized matter, *e.g.* dead protoplasm. These the chemist cannot duplicate; for vitality and organization, as we have seen, are things that elude both his analysis and his synthesis. Even with respect to the production of organic substances, the parallelism between the living cell and the chemical laboratory is far from being a perfect one. Speaking of the metaplastic or organic products of cells, Benjamin Moore says: "Most of these are so complex that they have not yet been synthesized by the organic chemist; nay, even of those that have been synthesized, it may be remarked that all proof is wanting that the syntheses have been carried out in identically the same fashion and by the employment of the same forms of energy in the case of the cell as in the chemist's laboratory. The conditions in the cell are widely different, and at the temperature of the cell and with such chemical materials as are at hand in the cell no such organic syntheses have been artificially carried out by the forms of energy extraneous to living tissue." ("Recent Advances in Physiology and Bio-Chemistry," p. 10.) Be that as it may, however, the prospect of a laboratory synthesis of an organic substance like chlorophyll affords no ground whatever for expecting a chemical synthesis of living matter. The chlorophyllic tail is inadequate to the task of wagging the dog of organic life. In this connection, Yves Delage's sarcastic comment on Schaaffhausen's theory is worthy of recall. The latter had suggested (in 1892) that life was initiated by a chemical reaction, in which water, air, and mineral salts united under the influence of light and heat

to produce a colorless *Protococcus*, which subsequently acquired chlorophyll and became a *Protococcus viridis*. "If the affair is so simple," writes Delage, "why does not the author produce a few specimens of this *protococcus* in his laboratory? We will gladly supply him with the necessary chlorophyll." ("La structure du protoplasma et les théories sur l'hérédité," p. 402.)

Another consideration, which never appears to trouble the visionaries who propound theories of this sort, is the fact that the inert elements and blind forces of inorganic nature are, if left to themselves, utterly impotent to duplicate even so much as the feats of the chemical laboratory, to say nothing at all of the more wonderful achievements possible only to living organisms. In the laboratory, the physicochemical forces of the mineral world are coördinated, regulated, and directed by the guiding intelligence of the chemist. In that heterogeneous conglomerate, which we call brute matter, no such guiding principle exists, and the only possible automatic results are those which the fortuitous concurrence of blind factors avails to produce. Chance of this kind may vie with art in the production of relatively simple combinations or systems, but where the conditions are as complex as those, which the synthesis of chlorophyll presupposes, chance is impotent and regulation absolutely imperative. How much more is this true, when there is question of the production of an effect so complicatedly telic as the living organism! "I venture to think," says Sir William Tilden, in a letter to the London *Times* (Sept. 10, 1912), "that no chemist will be prepared to suggest a process by which, from the interaction of such materials (viz., inorganic substances), anything approaching a substance of the nature of a proteid could be formed or, if by a complex series of changes a compound of this kind were conceivably produced, that it would present the characters of living protoplasm." In the concluding sentence of his letter, the great chemist seems to deprecate even the discussion of a chemical synthesis of living matter, whether

spontaneous or artificial. "Far be it from any man of science," he says, "to affirm that any given set of phenomena is not a fit subject of inquiry and that there is any limit to what may be revealed in answer to systematic and well-directed investigation. In the present instance, however, it appears to me that this is not a field for the chemist nor one in which chemistry is likely to afford any assistance whatever." In any case, the idea that a chaos of unassorted elements and undirected forces could succeed where the skill of the chemist fails is preposterous. No known or conceivable process, or group of processes, at work in inorganic nature, is equal to the task. Chance is an explanation only for minds insensible to the beauty and order of organic life.

Darwin inoculated biological science with this Epicurean metaphysics, when, in his "Origin of Species," he ascribed discriminating and selective powers of great delicacy and precision to the blind factors of a heterogeneous and variable environment. He compared natural selection to artificial selection, and in so doing, he was led astray by a false implication of his own analogy—"I have called this principle," he says, "by which each slight variation, if useful, is preserved, by the term natural selection, in order to mark its relation to man's power of selection." ("Origin of Species," 6th ed., c. III, p. 58.) Having likened the unintelligent and fortuitous selection and elimination exercised by the environment to the intelligent and purposive selection and elimination practiced by animal breeders and horticulturists, he pressed the analogy to the unwarranted extent of attributing to a blind, lifeless, and impersonal aggregate of minerals, liquids, and gases superhuman powers of discretion. To preserve even the semblance of parity, he ought first to have expurgated the process of artificial selection by getting rid of the element of human intelligence, which lurks therein, and vitiates its parallelism with the unconscious and purposeless havoc wrought at random by the blind and uncoördinated agencies of the environment. If inorganic nature were a vast

and multifarious mold, a preformed sieve with holes of different sizes, a separator for sorting coins of various denominations, Darwin's idea would be, in some degree, defensible, but this would only transfer the problem of cosmic order and intelligence from the organism to the environment. As a matter of fact, the mechanism of the environment is far too *simple* in its structure and too *general* in its influence to account for the complexities and specificities of organisms, that is, for the morphology and specific differences of plants and animals. Hence the selective work of the environment is negligible in the positive sense, and consists, for the most part, in a tendency to eliminate the abnormal and the subnormal. On the other hand, the environment as well as the organism is fundamentally teleological, and the environmental mechanism, though simple and general, is nevertheless expressly preadapted for the maintenance of organic life. Henderson, the bio-chemist of Harvard, has shown conclusively, in his "Fitness of the Environment" (1913), that the environment itself has been expressly selected with this finality in view, and that the inorganic world, while not the active cause, is, nevertheless, the preördained complement of organic life.

Simple constructions may, indeed, be due to pure accident as well as deliberate art, inasmuch as they presuppose but few and easy conditions. Complex constructions, on the contrary, provided they be systematic and not chaotic, are not producible by accident, but only by art, because they require numerous and complicated conditions. Operating individually, the unconscious factors of inorganic nature can produce simple and homogeneous constructions such as crystals. Operating in uncoördinated concurrence with one another, these blind and unrelated agencies produce complex chaotic formations such as mountains and islands, mere heterogeneous conglomerates, destitute of any determinate size, shape, or symmetry, constructions in which every single item and detail is the result of factors each of which is independent of the

other. In short, the efficacy of the unconscious and uncoordinated physicochemical factors of inorganic nature is limited to fortuitous results, which serve no purpose, embody no intelligible law, convey no meaning nor idea, and afford no æsthetic satisfaction, being mere aggregates or sums rather than natural units and real totalities. But it does not extend to the production of complex systematic formations such as living organisms or human artefacts. Left to itself, therefore, inorganic nature might conceivably duplicate the simplest artefacts such as the chipped flints of the savage, and it might also construct a complex heterogeneous chaos of driftwood, mud, and sand like the Great Raft of the Red River, but it would be utterly impotent to construct a complicated telic system comparable to an animal, a clock, or even an organic compound, like chlorophyll.

In this connection, it is curious to note how extremely myopic the scientific materialist can be, when there is question of recognizing a manifestation of Divine intelligence in the stupendous teleology of the living organism, and how incredibly lynx-eyed he becomes, when there is question of detecting evidences of human intelligence in the eoliths alleged to have been the implements of a "Tertiary Man." In the latter case, he is never at a loss to determine the precise degree of chipping, at which an eolith ceases to be interpretable as the fortuitous product of unconscious processes, and points infallibly to the intelligent authorship of man, but he grows strangely obtuse to the psychic implications of teleology, when it comes to explaining the symmetry of a starfish or the beauty of a Bird of Paradise.

In conclusion, it is clear that the hypothesis of a spontaneous origin of organic life from inorganic matter has in its favor neither factual evidence nor aprioristic probability, but is, on the contrary, ruled out of court by the whole force of the scientific principle of induction. To recapitulate, there are no sub-cellular organisms, and all cellular organisms (which is the same as saying, all organisms), be they unicellular or

multicellular, originate exclusively by reproduction, that is, by generation from living parents of the same organic type or species. This is the law of genetic vital continuity, which, by the way, Aristotle had formulated long before Harvey, when he said: "It appears that all living beings come from a germ, and the germ from parents." ("De Generatione Animalium," lib. I, cap. 17.) All reproduction, however, is reducible to a process of cell-division. That such is the case with unicellular organisms is evident from the very definition of a cell. That it is also true of multicellular organisms can be shown by a review of the various forms of reproduction occurring among plants and animals.

§ 4. Reproduction and Rejuvenation

Reproduction, the sole means by which the torch of life is relayed from generation to generation, the exclusive process by which living individuals arise and races are perpetuated, consists in the separation of a germ from the parent organism as a physical basis for the development of a new organism. The germ thus separated may be many-celled or one-celled, as we shall see presently, but the separated cells, be they one or many, have their common and exclusive source in the process of mitotic cell-division. In a few cases, this divisional power or energy of the cell seems to be perennial by virtue of an inherent inexhaustibility. In most cases, however, it is perennial by virtue of a restorative process involving nuclear reorganization. In the former cases, which are exceptional, the cellular stream of life appears to flow onward forever with steady current, but as a general rule it ebbs and flows in cycles, which involve a periodic rise and fall of divisional energy. The phenomena of the life-cycle are characteristic of most, perhaps all, organisms. The complete life-cycle consists of three phases or periods, namely: an adolescent period of high vitality, a mature period of balanced metabolism, and a senescent period of decline. Each life-cycle begins with the germination of the new organism

and terminates with its death, and it is reproduction which constitutes the connecting link between one life-cycle and another.

Reproduction, as previously intimated, is mainly of two kinds, namely: somatogenic reproduction, which is less general and confined to the metists, and cytogenic reproduction, which is common to metists and protists, and which is the ordinary method by which new organisms originate. Reproduction is termed somatogenic, when the germ separated from the body of the parent consists of a whole mass of somatic or tissue cells not expressly set aside and specialized for reproductive purposes. Reproduction is termed cytogenic, when the germ separated from the parent or parents consists of a single cell (*e.g.* a spore, gamete, or zygote) dedicated especially to reproductive purposes.

Cytogenic reproduction may be either nonsexual (agamic) or sexual, according as the cell which constitutes the germ is an agamete or a gamete. An agamete is a germ cell not specialized for union with another complementary cell, or, in other words, it is a reproductive cell incapable of syngamy, *e.g.* a spore. A gamete, on the other hand, is a reproductive cell (germ cell) specialized for the production of a zygote (a synthetic or diploid germ cell) by union with a complementary cell, *e.g.* an egg, or a sperm.

Nonsexual cytogenic reproduction is of three kinds, according to the nature of the agamete. When a unicellular organism gives rise to two new individuals by simple cell-division, we have fissiparation or binary fission. When a small cell or bud is formed and separated by division from a larger parent cell, we have budding (gemmation) or unequal fission. When the nucleus of the parent cell divides many times to form a number of daughter-nuclei, which then partition the cytoplasm of the parent cell among themselves so as to form a large number of reproductive cells called spores, we have what is known as sporulation or multiple fission. The first and second kind of nonsexual

reproduction are confined to the protists, but the third kind (sporulation) also occurs among the metists.

Sexual cytogenic reproduction is based upon gametes or mating germ cells. Since complementary gametes are specialized for union with each other to form a single synthetic cell, the zygote, the number of their nuclear threads or chromosomes is reduced to one half (the *haploid number*) at the time of maturation, so that the somatic or tissue cells of the parent organism have double the number (the *diploid number*) of chromosomes present in the reduced or mature gametes. Hence, when the gametes unite to form a zygote, summation is prevented and the diploid number of chromosomes characteristic of the given species of plant or animal is simply restored by the process of syngamy or union. The process by which the number of chromosomes is reduced in gametes is called *meiosis*, and, among the metists, it is distinct from syngamy, which, in their case, is a separate process called fertilization. Among the protists, we have, besides fertilization, another type of syngamy called conjugation, which combines meiosis with fertilization.

In sexual reproduction, we have three kinds of gametes, namely: isogametes, anisogametes, and heterogametes. In the type of sexual reproduction known as isogamy, the complementary gametes are exactly alike both in size and shape. There is no division of labor between them. Each of the fusing gametes is equally fitted for the double function which they must perform, namely, the kinetic function, which enables them to reach each other and unite by means of movement, and the trophic function which consists in laying up a store of food for the sustenance of the developing embryo. In anisogamy, the complementary gametes are alike in shape, but unlike in size, and here we have the beginning of that division of labor, upon which the difference of gender or sex is based. The larger or female gamete is called a macrogamete. It is specialized for the trophic rather than the kinetic function, being rendered more inert by having a large

amount of yolk or nutrient material stored up within it. The smaller or male gamete is called a microgamete. It is specialized for the kinetic function, since it contains less yolk and is the more agile of the two. In anisogamy, however, the division of labor is not complete, because both functions are still retained by either gamete, albeit in differing measure. In the heterogamy, the differentiation between the male and female gametes is complete, and they differ from each other in structure as well as size. The larger or female gamete has no motor apparatus and retains only the trophic function. The kinetic function is sacrificed to the task of storing up a food supply for the embryo. Such a gamete is called a hypergamete or egg. The smaller or male gamete is known, in this case, as a hypogamete or sperm. It has a motor apparatus, but no stored-up nutrients, and has even sloughed off most of its cytoplasm, in its exclusive specialization for the motor function. In heterogamy, accordingly, the division of labor is complete.

We may distinguish two principal kinds of sexual reproduction, namely: unisexual reproduction and bisexual reproduction. When a single gamete such as an unfertilized egg gives rise (with, or without, chromosomal reduction) to a new organism, we have unisexual reproduction or parthenogenesis. Parthenogenesis from a reduced egg gives rise to an organism having only the haploid number of chromosomes, as is the case with the drone or male bee, but unreduced eggs give rise to organisms having the diploid number of chromosomes. Parthenogenesis, as we shall see presently, can, in some cases, be induced by artificial means. When reproduction takes place from a zygote or diploid germ cell formed by the union of two gametes, we have what is known as bisexual reproduction or syngamy. It is, perhaps, permissible to distinguish a third or intermediate kind of sexual reproduction, for which we might coin the term autosexual. What we refer to as autosexual reproduction is usually known as autogamy, and occurs when a diploid nucleus is formed in a germ

cell by the union (or, we might say, reunion) of two daughter-nuclei derived from the same mother-nucleus. Autogamy occurs not only among the protists (*e.g. Amœba albida*), but also among the metists, as is the case with the brine shrimp, *Artemia salina,* in which the diploid number of chromosomes is restored after reduction by a reunion of the nucleus of the second polar body with the reduced nucleus of the egg. Autogamy is somewhat akin to kleistogamy, which occurs among hermaphroditic metists of both the plant and animal kingdoms. The violet is a well-known example. In kleistogamy or self-fertilization, the zygote is formed by the union of two gametes derived from the same parent organism. Strictly speaking, however, kleistogamy is not autogamy, but syngamy, and must, therefore, be classed as bisexual reproduction. It is, of course, necessarily confined to hermaphrodites.

Loeb's experiments in artificial parthenogenesis have been sensationally misinterpreted by some as an artificial production of life. What Jacques Loeb really did was to initiate development in an unfertilized egg by the use of chemical and physical excitants. The writer has repeated these experiments with the unfertilized eggs of the common sea urchin, *Arbacia punctulata,* using very dilute butyric acid and hypertonic sea water as stimulants. Cleavage had started within an hour and a half after the completion of the aforesaid treatment, and the eggs were in the gastrula stage by the following morning (9 hours later). In three days, good specimens of the larval stage known as the pluteus could be found swimming in the normal sea water to which the eggs had been transferred from the hypertonic solution. Since mature sea urchin eggs undergo reduction before insemination takes place, the larval sea urchins arising from these artificially activated eggs had the reduced or haploid number of chromosomes instead of the diploid number possessed by normal larvæ arising from eggs activated by the sperm. For, in fertilization, the sperm not only activates the egg, but is also the means of secur-

ing biparental inheritance, by contributing its quota of chromosomes to the zygotic complex. Hence, it is only in the former function, *i.e. of* initiating cleavage in the egg, that a chemical excitant can replace the sperm. In any case, it is evident that these experiments do not constitute an exception to the law of genetic cellular continuity. The artificially activated egg comes from the ovaries of a living female sea urchin, and in this there is small consolation for the exponent of abiogenesis. The terse comment of an old Irish Jesuit sizes up the situation very aptly: "The Blue Flame Factory," he said, "has announced another discovery of the secret of life. A scientist made an egg and hatched an egg. The only unfortunate thing was that the egg he hatched was not the egg he made." How an experiment of this sort could be interpreted as an artificial production of life is a mystery. The only plausible explanation is that given by Professor Wilson, who traces it to the popular superstition that the egg is a lifeless substrate, which is animated by the sperm. The idea owes its origin to the spermists of the 17th century, who defended this doctrine against the older school of preformationists known as ovists. It is now, however, an embryological commonplace that egg and sperm are both equally cellular, equally protoplasmic, and equally vital.

The phenomena of the life-cycle in organisms find their explanation in what, perhaps, is inherent in all living matter, namely, a tendency to involution and senescence. This tendency, in the absence of a remedial process of rejuvenation, leads inevitably to death. Living matter seems to "run down" like a clock, and to stand in similar need of a periodic "rewinding." This reinvigoration of protoplasm is accomplished by means of several different types of nuclear reorganization. Since no nuclear reorganization occurs in somatogenic reproduction, there seem to be limits to this type of propagation. Plants, like the potato and the apple, cannot be propagated indefinitely by means of tubers, shoots, stems, etc. The stock plays out in time, and, ever and anon, recourse must

be had to seedlings. Hence a process of nuclear reorganization seems, in most cases, at least, to be essential for the restoration of vitality and the continuance of life. Whether this need of periodic renewal is absolutely universal, we cannot say. The banana has been propagated for over a century by the somatogenic method, and there are a few other instances in which there appears to be no limit to this type of reproduction. Nevertheless, the tendency to decline is so common among living beings that the rare exceptions serve only to confirm (if they do not follow) the general rule.

In cytogenic reproduction three kinds of rejuvenation by means of nuclear reorganization are known: (1) amphimixis or syngamy; (2) automixis or autogamy; (3) endomixis. In amphimixis or syngamy, two gametic (haploid) nuclei of different parental lineage are commingled to form the diploid nucleus of the zygote, which is consequently of biparental origin. In automixis or autogamy, two reduced or haploid nuclei of the same parental lineage unite to form a diploid nucleus, the uniting nuclei being daughter-nuclei derived from a common parent nucleus. In endomixis, the nucleus of the exhausted cell disintegrates and fuses with the cytoplasm, out of which it is reformed or reconstructed as the germinal nucleus of a rejuvenated cellular series. Endomixis occurs as a periodic phenomenon among the protists, and it appears to be homologous with parthenogenesis among metists. In certain ciliates, like the Paramoecium, endomixis and syngamy are facultative methods of rejuvenation. This has been proved most conclusively by Professor Calkins' work on *Uroleptus mobilis,* an organism in which both endomixis and conjugation are amenable to experimental control. Nonsexual reproduction in this protozoan (by binary fission) is attended with a gradual weakening of metabolic activity, which increases with each successive generation. The initial rate of division and metabolic energy can, however, be restored either by conjugation (of two individuals), or by endomixis, which takes place (in a single individual) during encyst-

ment. The race, however, inevitably dies out, if both encystment and conjugation are prevented. Even in such protists as do not exhibit the phenomenon of nuclear reorganization through sexual reproduction, Kofoid points to the phenomenon of alternating periods of rest and rapid cell-division as evidence that some process of periodically-recurrent nuclear organization must exist in the organisms, which do not conjugate. This process of nuclear reorganization manifested by periodic spurts of renewed divisional energy is, according to Kofoid, a more primitive mode of rejuvenation than endomixis. "The phenomenon of endomixis," he says, "appears to be somewhat more like that of parthenogenesis than a more primitive form of nuclear reorganization." (*Science,* April 6, 1923, p. 403.) At all events, it seems safe to conclude that the tendency to senescence is pretty general among living organisms, and that this tendency, unless counteracted by a periodic reorganization of the nuclear genes, results inevitably in the deterioration and final extinction of the race.

In this inexhaustible power of self-renewal inherent in all forms of organic life, the mechanist and the upholder of abiogenesis encounter an insuperable difficulty. In inorganic nature, where the perpetual-motion device is a chimera, and the law of entropy reigns in unchallenged supremacy, nothing analogous to it can be found. The activity of all non-living units of nature, from the hydrogen atom to the protein multimolecule, is rigidly determined by the principle of the degradation of energy. The inorganic unit cannot operate otherwise than by externalizing and dissipating irreparably its own energy-content. Nor is its reconstruction and replenishment with energy ever again possible except through the wasteful expenditure of energy borrowed from some more richly endowed inorganic unit. In order to pay Paul a little, Peter must be robbed of much. Wheresoever atoms are built up into complex endothermic molecules, the constructive

process is rigidly dependent upon the administration thereto of external energy, which in the process of absorption must of necessity fall from a higher level of intensity. And when the energy thus absorbed by the complex molecule is again set free by combustion, it is degraded to a still lower potential, from which, without external intervention, it can never rise again to its former plane of intensity. The phenomena of radioactivity tell the same tale. All the heavier atoms, at least, are constantly disintegrating with a concomitant discharge of energy. There is no compensating process, however, enabling such an atom to re-integrate and recharge itself at stated intervals; and, once it has broken down into its component protons and electrons, "not all the king's horses nor all the king's men can ever put Humpty-Dumpty together again." In a word, none of the inorganic units of the mineral world exhibits that wonderful power of autonomous recuperation which a unicellular ciliate manifests when it rejuvenates itself by means of endomixis. The inorganic world knows of no constructive process comparable to this. It is only in living beings that we find what James Ward describes as the "tendency to disturb existing equilibria, to reverse the dissipative processes which prevail throughout the inanimate world, to store and build up where they are ever scattering and pulling down, the tendency to conserve individual existence against antagonistic forces, to grow and to progress, not inertly taking the easier way but seemingly striving for the best, retaining every vantage secured, and working for new ones." ("On the Conservation of Energy," I, p. 285.)

Summing up, then, we have seen that the reproductive process, whereby the metists or multicellular organism originate, resolves itself ultimately into a process of cell-division. The same is true of the protists or unicellular organisms. For all cells, whether they be protists, germ cells, or somatic cells, originate in but one way, and that is, from a preëxistent living cell by means of cell-division. Neither experimentation

nor observation has succeeded in revealing so much as a single exception to the universal law of genetic cellular continuity, and the hypothesis of spontogenesis is outlawed, in consequence, by the logic of scientific induction. Even the hope that future research may bring about an amelioration of its present status is entirely unwarranted in view of the manifest dynamic superiority of the living organism as compared with any of the inert units of the inorganic world. "Whatever position we take on this question," says Edmund B. Wilson, in the conclusion of his work on the Cell, "the same difficulty is encountered; namely, the origin of that coördinated fitness, that power of active adjustment between internal and external relations, which, as so many eminent biological thinkers have insisted, overshadows every manifestation of life. The nature and origin of this power is the fundamental problem of biology. When, after removing the lens of the eye in the larval salamander, we see it restored in perfect and typical form by regeneration from the posterior layer of the iris, we behold an adaptive response to changed conditions of which the organism can have no antecedent experience either ontogenetic or phylogenetic, and one of so marvelous a character that we are made to realize, as by a flash how far we still are from a solution of this problem." Then, after discussing the attempt of evolutionists to bridge the enormous gap that separates living, from lifeless nature, he continues: "But when all these admissions are made, and when the conserving action (*sic*) of natural selection is in the fullest degree recognized, we cannot close our eyes to two facts: first, that we are utterly ignorant of the manner in which the idioplasm of the germ cell can so respond to the influence of the environment as to call forth an adaptive variation; and second, that the study of the cell has on the whole seemed to widen rather than to narrow the enormous gap that separates even the lowest forms of life from the inorganic world." ("The Cell," 2nd edit., pp. 433, 434.)

§ 5. A "New" Theory of Abiogenesis

Since true science is out of sympathy with baseless conjectures and gratuitous assumptions, one would scarcely expect to find scientists opposing the inductive trend of the known facts by preferring mere possibilities (if they are even such) to solid actualities. As a matter of fact, however, there are not a few who obstinately refuse to abandon preconceptions for which they can find no factual justification. The bio-chemist, Benjamin Moore, while conceding the bankruptcy of the old theory of spontaneous generation, which looked for a *de novo* origin of living cells in sterilized cultures, has, nevertheless, the hardihood to propose what he is pleased to term a *new* one. Impressed by the credulity of Charlton Bastian and the autocratic tone of Schäfer, he sets out to defend as plausible the hypothesis that the origination of life from inert matter may be a contemporaneous, perhaps, daily, phenomenon, going on continually, but invisible to us, because its initial stages take place in the submicroscopic world. By the time life has emerged into the visible world, it has already reached the stage at which the law of genetic continuity prevails, but at stages of organization, which lie below the limit of the microscope, it is not impossible, he thinks, that abiogenesis may occur. To plausibleize this conjecture, he notes that the cell is a natural unit composed of molecules as a molecule is a natural unit composed of atoms. He further notes, that, in addition to the cell, there is in nature another unit higher than the monomolecule, namely, the *multimolecule* occurring in both crystalloids and colloids. The monomolecule consists of atoms held together by atomic valence, whereas the multimolecule consists of molecules whose atomic valence is completely saturated, and which are, consequently, held together by what is now known as *molecular* or *residual valence*. Moore cites the crystal units of sodium bromide and sodium iodide as instances of multimolecules. The crystal unit of ordinary salt, sodium chloride, is an ordinary monomolecule, with the for-

mula NaCl. In the case of the former salts the crystal units consist of multimolecules of the formula $NaB \cdot (H_2O)_2$ and $NaI \cdot (H_2O)_2$, the water of crystallization not being mechanically confined in the crystals, but combined with the respective salt in the exact ratio of two molecules of water to one of the salt. Judged by all chemical tests, such as heat of formation, the law of combination in fixed ratios, the manifestation of selective affinity, etc., the multimolecule is quite as much entitled to be considered a natural unit as is the monomolecule.

But it is not in the crystalloidal multimolecule, but in the larger and more complex multimolecule of colloids (viscid substances like gum arabic, gelatine, agar-agar, white of egg, etc.), that Moore professes to see a sort of intermediate between the cell and inorganic units. Such colloids form with a dispersing medium (like water) an emulsion, in which the dispersed particles, known as ultramicrons or "solution aggregates," are larger than monomolecules. It is among these multimolecules of colloids that Moore would have us search for a transitional link connecting the cell with the inorganic world. Borrowing Herbert Spencer's dogma of the complication of homogeneity into heterogeneity, he asserts that such colloidal multimolecules would tend to become more and more complex, and consequently more and more instable, so that their instability would gradually approach the chronic instability or constant state of metabolic fluxion manifest in living organisms. The end-result would be a living unit more simply organized than the cell, and evolution seizing upon this submicroscopic unit would, in due time, transform it into cellular life of every variety and kind. *Ce n'est que le premier pas qui coûte!*

It should be noted that this so-called law is a mere vague formula like the "law" of natural selection and the "law" of evolution. The facts which it is alleged to express are not cited, and its terms are far from being quantitative. It is certainly not a law in the sense of Arrhénius, who says:

"Quantitative formulation, that is, the establishing of a connection, expressed by a formula, between different quantitatively measurable magnitudes, is the peculiar feature of a law." ("Theories of Chemistry," Price's translation, p. 3.) Now, chemistry, as an exact science, has no lack of laws of this kind, but no branch of chemistry, whether physical, organic, or inorganic, knows of any *law of complexity*, that can be stated in either quantitative, or descriptive, terms. We will, however, let Moore speak for himself:

"It may then be summed up as a general law universal in its application to all matter, . . . a law which might be called the Law of Complexity, that matter so far as its energy environment will permit tends to assume more and more complex forms in labile equilibrium. Atoms, molecules, colloids, and living organisms, arise as a result of the operations of this law, and in the higher regions of complexity it induces organic evolution and all the many thousands of living forms. . . .

"In this manner we can conceive that the hiatus between non-living and living things can be bridged over, and there awakens in our minds the conception of a kind of spontaneous production of life of a different order from the old. The territory of this spontaneous generation of life lies not at the level of bacteria, or animalculæ, springing forth into life from dead organic matter, but at a level of life lying deeper than anything the microscope can reveal, and possessing a lower unit than the living cell, as we form our concept of it from the tissues of higher animals and plants.

"In the future, the stage at which colloids begin to be able to deal with external energy forms, such as light, and build up in chemical complexity, will yield a new unit of life opening a vista of possibilities as magnificent as that which the establishment of the cell as a unit gave, with the development of the microscope, about a century ago." ("Origin and Nature of Life," pp. 188-190.)

Having heard out a rhapsody of this sort, one may be

pardoned a little impatience at such a travesty on science. Again we have the appeal from realities to fancies, from the seen to unseen. Moore sees no reason to doubt and is therefore quite sure that an unverified occurrence is taking place "at a level of life lying deeper than anything the microscope can reveal." The unknown is a veritable paradise for irresponsible speculation and phantasy. It is well, however, to keep one's feet on the *terra firma* of ascertained facts and to make one's ignorance a motive for caution rather than an incentive to reckless dogmatizing.

To begin with, it is not to a single dispersed particle or ultramicron that protoplasm has been likened, but to an emulsion, comprising both the dispersed particles and the dispersing medium, or, in other words, to the colloidal system as a whole. Moreover, even there the analogy is far from being perfect, and is confined exclusively, as Wilson has pointed out, to a rough similarity of structure and appearance. The colloidal system is obviously a mere *aggregate* and not a *natural unit* like the cell, and its dispersed particles (ultramicrons) do not multiply and perpetuate themselves by growth and division as do the living components or formed bodies of the cell. As for the single ultramicron or multimolecule of a colloidal solution, it may, indeed, be a natural unit, but it only resembles the cell in the sense that, like the latter, it is a complex of constituent molecules. Here, however, all resemblance ceases; for the ultramicron does not display the typically vital power of self-perpetuation by growth and division, which, as we have seen, is characteristic not only of the cell as a whole, but of its single components or organelles. Certainly, the distinctive phenomena of colloidal systems cannot be interpreted as processes of multiplication. There is nothing suggestive of this vital phenomenon in the reversal of phase, which is caused by the addition of electrolytes to oil emulsions, or in gelation, which is caused by a change of temperature in certain hydrophilic colloids. Thus the addition of the salt of a bivalent cation (*e.g.* $CaCl_2$ or $BaCl_2$) to an oil-in-water emulsion (if

soap is used as the emulsifier) will cause the external or continuous phase (water) to become the internal or discontinuous phase. Vice versa, a water-in-oil emulsion can be reversed into an oil-in-water emulsion, under the same conditions, by the addition of the salt of a monovalent cation (*e.g.* NaOH). Solutions of hydrophilic colloids, like gelatine or agar-agar, can be made to "set" from the semifluid state of a hydrosol into the semisolid state of a hydrogel, by lowering the temperature, after which the opposite effect can be brought about by again raising the temperature. In white of egg, however, once gelation has taken place, through the agency of heat, it is impossible to reconvert the "gel" into a "sol" (solution). In such phenomena, it is, perhaps, possible to see a certain parallelism with some processes taking place in the cell, *e.g.* the osmotic processes of absorption and excretion, but to construe them as evidence of propagation by growth and division would be preposterous.

Nor is the subterfuge of relegating the question to the obscurity of the submicroscopic world of any avail; for, as a matter of fact, submicroscopic organisms actually do exist, and manage, precisely by virtue of this uniquely vital power of multiplication or reproductivity, to give indirect testimony of their invisible existence. The microörganisms, for example, which cause the disease known as Measles are so minute that they pass through the pores of a porcelain filter, and are invisible to the highest powers of the microscope. Nevertheless, they can be bred in the test tube cultures of the bacteriologist, where they propagate themselves for generations without losing the definite specificity, which make them capable of producing distinctive pathological effects in the organisms of higher animals, including man. Each of these invisible disease germs communicates but one disease, with symptoms that are perfectly characteristic and definite. Moreover, they are specific in their choice of a host, and will not infect any and every organism promiscuously. Finally, they never arise *de novo* in a healthy host, but must

always be transmitted from a diseased to a healthy individual. The microscopist is tantalized, to quote the words of Wilson, "with visions of disease germs which no eye has yet seen, so minute as to pass through a fine filter, yet beyond a doubt self-perpetuating and of specific type." (*Science,* March 9, 1923, p. 283.) Submicroscopic dimensions, therefore, are no obstacle to the manifestation of such vital properties as reproduction, genetic continuity, and typical specificity; and we must conclude that, if any of the ultramicrons of colloids possessed them, their minute size would not debar them from manifesting the fact. As it is, they fail to show any vital quality, whereas the submicroscopic disease germs give evidence of possessing all the characteristics of visible cells.

In fine, the radical difference between inorganic units, like atoms, molecules, and multimolecules, and living units, like protozoans and metazoans, is so obvious that it is universally admitted. Not all, however, are in accord when it comes to assigning the fundamental reason for the difference in question. Benjamin Moore postulates a unique physical energy, peculiar to living organisms and responsible for all distinctively vital manifestations. This unique form of energy, unlike all other forms, he calls "biotic energy," denying at the same time that it is a vital force. (Cf. *op. cit.,* pp. 224-226.) Moore seems to be desirous of dressing up vitalism in the verbal vesture of mechanism. He wants the game, without the name. But, if his "biotic energy" is unlike all other forms of energy, it ought not to parade under the same name, but should frankly call itself a "vital force." Somewhat similar in nature is Osborn's suggestion that the peculiar properties of living protoplasm may be due to the presence of a unique chemical element called Bion. (Cf. "The Origin and Evolution of Life," 1917, p. 6.) Now, a chemical element unlike other chemical elements is not a chemical element at all. Osborn's Bion, like Moore's biotic energy, ought, by all means, to make up its mind definitely on Hamlet's question

of "to be, or not to be." The policy of "It is, and it is not," is not likely to win the approval of either mechanists or vitalists.

§ 6. Hylomorphism versus Mechanism and Neo-vitalism

Mechanism and Neo-vitalism represent two extreme solutions of this problem of accounting for the difference between living and lifeless matter. Strictly speaking, it is an abuse of language to refer to mechanism as a solution at all. Its first pretense at solving the problem is to deny that there is any problem. But facts are facts and cannot be disposed of in this summary fashion. Forced, therefore, to face the actual fact of the uniqueness of living matter, mechanists concede the inadequacy of their physicochemical analogies, but obstinately refuse to admit the legitimacy of any other kind of explanation. Confronted with realities, which simply must have *some* explanation, they prefer to leave them unexplained by their own theory than have them explained by any other. They recognize the difference between a living animal and a dead animal (small credit to them for their perspicacity!), but deny that there is anything present in the former which is not present in the latter.

Neo-vitalism, on the other hand, is, at least, an attempt at solving the problem in the positive sense. It ascribes the unique activities of living organisms to the operation of a superphysical and superchemical energy or force resident in living matter. This unique dynamic principle is termed *vital force.* It is not an entitive nor a static principle, but belongs to the category of efficient or active causes, being variously described as an agent, energy, or force. To speak precisely, the term agent denotes an active being or substance; the term energy denotes the proximate ground in the agent of a specific activity; while the term force denotes the activity or free, kinetic, or activated phase of a given energy. In practice, however, these terms are often used interchangeably. Thus Driesch, who, like all other Neo-vitalists, makes the vital prin-

ciple a dynamic factor rather than an entitive principle, refers to the vital principle as a "non-material," "non-spatial" *agent,* though the term *energy* would be more precise. To this active or dynamic vital principle Driesch gives a name, which he borrowed from Aristotle, that is, *entelechy.* In so doing, however, he perverted, as he himself confesses, the true Aristotelian sense of the term in question: "The term," he says, ". . . is not here used in the proper Aristotelian sense." ("History and Theory of Vitalism," p. 203.) His admission is quite correct. At the critical point, Driesch, for all his praise of Aristotle, deserts the Stagirite and goes over to the camp of Plato, Descartes, and the Neo-vitalists!

Driesch's definition is as follows: "Entelechy is an agent *sui generis,* non-material and non-spatial, but acting 'into' space." (*Op. cit.,* p. 204.) Aristotle's use of the term in this connection is quite different. He uses it, for example, in a static, rather than a dynamic, sense: "The term 'entelechy,'" he says, "is used in two senses; in one it answers to knowledge, in the other to the exercise of knowledge. Clearly in this case it is analogous to knowledge." ("Peri Psyches," Bk. II, c. 1.) Knowledge, however, is only a *second* or static *entelechy.* Hence, in order to narrow the sense still further Aristotle refers to the *soul* as a *first* entelechy, by which he designates a purely *entitive* principle, that is, a constituent of being or substance (cf. *op. cit. ibidem*). The *first,* or entitive, entelechy, therefore, is to be distinguished from all secondary entelechies, whether of the *dynamic* order corresponding to kinetic energy or force, or of the *static* order corresponding to potential energy. Neither is it an *agent,* because it is only a partial constituent of the total agent, that is, of the total active being or substance. Hence, generally speaking, *that which acts* (the agent) is not entelechy, but the total composite of entelechy and matter, *first entelechy* being consubstantial with matter and not a separate existent or being. In fine, according to Aristotelian philosophy, entelechy (that is, "first" or "prime" entelechy) is not an agent nor an energy

nor a force. In other words, it is totally removed from the category of efficient or active causes. The second difference between Driesch and Aristotle with respect to the use of the term entelechy lies in the fact that Driesch uses it as a synonym for the soul or vital principle, whereas, according to Aristotle, *entelechy is common to the non-living units of inorganic nature as well as the living units* (organisms) *of the organic world.* All vital principles or souls are entelechies, but not all entelechies are vital principles. All material beings or substances, whether living or lifeless, are reducible, in the last analysis, to two consubstantial principles or complementary constituents, namely, entelechy and matter. Entelechy is the binding, type-determining principle, the source of unification and specification, which makes of a given natural unit (such as a molecule or a protozoan) a single and determinate whole. Matter is the determinable and potentially-multiple element, the principle of divisibility and quantification, which can enter indifferently into the composition of this or that natural unit, and which owes its actual unity and specificity to the entelechy which here and now informs it. It is entelechy which makes a chemical element distinct from its isobare, a chemical compound distinct from its isomer, a paramœcium distinct from an amœba, a maple distinct from an oak, and a bear distinct from a tiger.

The molecular entelechy finds expression in what the organic chemist and the stereochemist understand by valence, that is, the static aspect of valence considered as the structural principle of a molecule. Hence it is entelechy which makes a molecule of urea $[O{:}C{:}(NH_2)_2]$ an entirely different substance from its isomer ammonium cyanate $[NH_4{\cdot}O{\cdot}C{:}N]$, although the material substrate of each of these molecular units consists of precisely the same number and kinds of atoms. Similarly, it is the atomic entelechy which gives to the isotopes of Strontium chemical properties different from those of the isotopes of Rubidium, although the mass

and corpuscular (electronic and protonic) composition of their respective atoms are identical. It is the vital entelechy or soul, which causes a fragment cut from a Stentor to regenerate its specific protoplasmic architecture instead of the type which would be regenerated from a similar fragment cut from another ciliate such as Dileptus.

In all the tridimensional units of nature, both living and non-living, the hylomorphic analysis of Aristotle recognizes an essential dualism of matter and entelechy. Hence it is not in the presence and absence of an entelechy (as Driesch contends) that living organisms differ from inorganic units. The sole difference between these two classes of units is one of autonomy and inertia. The inorganic unit is inert, not in the sense that it is destitute of energy, but in the sense that it is incapable of self-regulation and rigidly dependent upon external factors for the utilization of its own energy-content. The living unit, on the other hand, is endowed with dynamic autonomy. Though dependent, in a general way, upon environmental factors for the energy which it utilizes, nevertheless the determinate form and direction of its activity is not imposed in all its specificity by the aforesaid environmental factors. The living being possesses a certain degree of independence with respect to these external forces. It is autonomous with a special law of immanent finality or reflexive orientation, by which all the elements and energies of the living unit are made to converge upon one and the same central result, namely, the maintenance and development of the organism both in its capacity as an individual and in its capacity as the generative source of its racial type.

The entelechies of the inert units of inorganic nature turn the forces of these units in an *outward direction,* so that they are incapable of operating upon themselves, of modifying themselves, or of regulating themselves. They are only capable of operating upon other units outside themselves, and in so doing they irreparably externalize their energy-contents. All physicochemical action is *transitive* or *communicable* in character,

whereas vital action is of the *reflexive* or *immanent* type. Mechanical action, for example, is intermolar (*i.e.* an exchange between large masses of inorganic matter); physical action is intermolecular; chemical action is interatomic; while in radioactive and electrical phenomena we have intercorpuscular action. Hence all the forms of activity native to the inorganic world are reducible to *interaction* between discontinuous and unequally energized masses or particles. Always it is a case of one mass or particle operating upon another mass or particle distinct from, and spatially external to, itself. The effect or positive change produced by the action is received into another unit distinct from the agent or active unit, which can never become the receptive subject of the effect generated by its own activity. The living being, on the contrary, is capable of operating upon itself, so that what is modified by the action is not outside the agent but within it. The reader does not modify the book, but modifies himself by his reading. The blade of grass can nourish not only a horse, but its very self, whereas a molecule of sodium nitrate is impotent to nourish itself, and can only nourish a subject other than itself, such as the blade of grass. Here the active source and receptive subject of the action is one and the same unit, namely, the living organism, which can operate upon itself in the interest of its own perfection. In chemical synthesis two substances interact to produce a third, but in vital assimilation one substance is incorporated into another without the production of a third. Thus hydrogen unites with oxygen to produce water. But in the case of assimilation the reaction may be expressed thus: Living protoplasm plus external nutriment equals living protoplasm increased in quantity but unchanged in specificity. Addition or subtraction alters the nature of the inorganic unit, but does not change the nature of the living unit. In chemical change, entelechy is the variant and matter is the constant, but in metabolic change, matter is the variant and entelechy the constant. "Living beings," says Henderson, "preserve, or tend to preserve, an ideal form, while through

them flows a steady stream of energy and matter which is ever changing, yet momentarily molded by life; organized, in short." ("Fitness of the Environment," 1913, pp. 23, 24.) The living unit maintains its own specific type amid a constant flux of matter and flow of energy. It subjugates the alien substances of the inorganic world, eliminates their mineral entelechies and utilizes their components and energies for its own purposes. The soul or vital entelechy, therefore, is more powerful than the entelechies of inorganic units which it supplants. It turns the forces of living matter *inward,* so that the living organism becomes capable of *self-regulation* and of striving for the attainment of self-perfection. It is this *reflexive orientation* of all energies towards self-perfection that is the unique characteristic of the living being, and not the nature of the energies themselves. The energies by which vital functions are executed are the ordinary physicochemical energies, but it is the vital entelechy or soul which elevates them to a higher plane of efficiency and renders them capable of reflexive or vital action. There is, in short, no such thing as a special vital force. The radical difference between living and non-living units does not consist in the possession or non-possession of an entelechy, nor yet in the peculiar nature of the forces displayed in the execution of vital functions, but solely in the orientation of these forces towards an inner finality.

§ 7. The Definition of Life

Life, then, may be defined as the capacity of reflexive or self-perfective action. In any action, we may distinguish four things: (1) the agent, or source of the action; (2) the activity or internal determination differentiating the agent in the active state from the selfsame agent in the inactive state; (3) the patient or receptive subject; (4) the effect or change produced in the patient by the agent. Let us suppose that a boy named Tom kicks a door. Here Tom is the agent, the muscular contraction in his leg is the activity, the door is the patient or recipient, while the dent produced in the door is

the effect or change of which the action is a production. In this action, the effect is produced not in the cause or agent, but in a patient outside of, and distinct from, the agent, and the otherness of cause and effect is consequently complete. Such an action is termed transitive, which is the characteristic type of physicochemical action. In another class of actions, however, (those, namely, that are peculiar to living beings) the otherness of cause and effect is only partial and relative. When the agent becomes ultimately the recipient of the effect or modification wrought by its own activity, that is, when the positive change produced by the action remains within the agent itself, the action is called immanent or reflexive action. Since, however, action and passion are opposites, they can coëxist in the same subject only upon condition that said subject is differentiated into partial otherness, that is, organized into a plurality of distinct and dissimilar parts or components, one of which may act upon another. Hence only the organized unit or organism, which combines unity or continuity of substance with multiplicity and dissimilarity of parts is capable of immanent action. The inorganic unit is capable only of transitive action, whose effect is produced in an exterior subject really distinct from the agent. The living unit or organism, however, is capable of both transitive action and immanent (reflexive) action. In such functions as thought and sensation, the living agent modifies itself and not an exterior patient. In the nutritive or metabolic function the living being perfects itself by assimilating external substances to itself. It develops, organizes, repairs, and multiplies itself, holding its own and perpetuating its type from generation to generation.

Life, accordingly, is the capacity of tending through any form of reflexive action to an ulterior perfection of the agent itself. This capacity of an agent to operate of, and upon, itself for the acquisition of some perfection exceeding its natural equilibrial state is the distinctive attribute of the living being. Left to itself, the inorganic unit tends ex-

clusively to conservation or to loss, never to positive acquisition in excess of equilibrial exigencies; what it acquires it owes exclusively to the action of external factors. The living unit, on the contrary, strives in its vital operations to acquire something for itself, so that what it gets it owes to itself and not (except in a very general sense) to the action of external factors. All the actions of the living unit, both upon itself and upon external matter, result sooner or later in the acquisition on the part of the agent of a positive perfection exceeding and transcending the mere exigencies of equilibration. The inorganic agent, on the contrary, when in the state of tension, tends only to return to the equilibrial state by alienation or expenditure of its energy; otherwise, it tends merely to conserve, by virtue of inertia, the state of rest or motion impressed upon it from without. In the chemical changes of inorganic units, the tendency to loss is even more in evidence. Such changes disrupt the integrity of the inorganic unit and dissipate its energy-content, and the unit cannot be reconstructed and recharged, except at the expense of a more richly endowed inorganic unit. The living organism, however, as we see in the case of the paramœcium undergoing endomixis, is capable of counteracting exhaustion by recharging itself.

The difference between transitive and reflexive action is not an accidental difference of *degree*, but an essential difference of *kind*. In reflexive actions, the source of the action and the recipient of the effect or modification produced by it are one and the same substantial unit or being. In transitive actions, the receptive subject of the positive change is an alien unit distinct from the unit, which puts forth the action. Hence a reflexive action is not an action which is *less* transitive; it is an action which is *not at all* transitive, but intransitive. The difference, therefore, between the living organism, which is capable of both reflexive and transitive action, and the inorganic unit, which is only capable of transitive action, is *radical* and *essential*. This being the case, an

evolutionary transition from an inert multimolecule to a reflexively-operating cell or cytode, becomes inconceivable. Evolution might, at the very most, bring about intensifications and combinations of the transitive agencies of the physicochemical world, but never the *volte face,* which would be necessary to reverse the centrifugal orientation of forces characteristic of the inorganic unit into the centripetal orientation of forces which makes the living unit capable of self-perfective action, self-regulation, and self-renewal. The idea, therefore, of a spontaneous derivation of living units from lifeless colloidal multimolecules must be rejected, not merely because it finds no support in the facts of experience, but also because it is excluded by aprioristic considerations.

§ 8. **An Inevitable Corollary**

But, if inorganic matter is impotent to vitalize itself by means of its native physicochemical forces, the inevitable alternative is that the initial production of organisms from inorganic matter was due to the action of some supermaterial agency. Certain scientists, like Henderson of Harvard, while admitting the incredibility of abiogenesis, prefer to avoid open conflict with mechanism and materialism by declaring their neutrality. "But while biophysicists like Professor Schäfer," says Henderson, "follow Spencer in assuming a gradual evolution of the organic from the inorganic, biochemists are more than ever unable to perceive how such a process is possible, and without taking any final stand prefer to let the riddle rest." ("Fitness of the Environment," p. 310, footnote.) Not to take a decisive stand on this question, however, is tantamount to making a compromise with what is illogical and unscientific; for both logic and the inductive trend of biological facts are arrayed against the hypothesis of spontaneous generation.

In the first place, it is manifest that organic life is neither self-explanatory nor eternal. Hence it must have had its origin in the action of some external agency. Life as it exists

to-day depends upon the precedence of numerous unbroken chains of consecutive cells that extend backward into a remote past. It is, however, a logical necessity to put an end to this retrogradation of the antecedents upon which the actual existence of our present organisms depends. The infinite cannot be spanned by finite steps; the periodic life-process could not be relayed through an unlimited temporal distance; and a cellular series which never started would never arrive. Moreover, we do not account for the existence of life by extending the cellular series interminably backward. Each cell in such a series is derived from a predecessor, and, consequently, no cell in the series is self-explanatory. When it comes to accounting for its own existence, each cell is a zero in the way of explanation, and adding zeros together indefinitely will never give us a positive total. Each cell refers us to its predecessor for the explanation of why it exists, and none contains within itself the sufficient explanation of its own existence. Hence increasing even to infinity the number of these cells (which fail to explain themselves) will give us nothing else but a zero in the way of explanation. If, therefore, the primordial cause from which these cellular chains are suspended is not the agency of the physicochemical forces of inorganic nature, it follows that the first active cause of life must have been a *supermaterial* and *extramundane agency*, namely, the Living God and Author of Life.

As a matter of fact, no one denies that life has had a beginning on our globe. The physicist teaches that a beginning of our entire solar system is implied in the law of the degradation of energy, and various attempts have been made to determine the time of this beginning. The older calculations were based on the rate of solar radiation; the more recent ones, however, are based on quantitative estimates of the disintegration products of radio-active elements. Similarly, the geologist and the astronomer propound theories of a gradual constitution of the cosmic environment, which organic life requires for its support, and all such theories imply a *de novo*

origin or beginning of life in the universe. Thus the old *nebular hypothesis* of Laplace postulated a hot origin of our solar system incompatible with the coëxistence of organic life, which, as the experiments of Pasteur and others have shown, is destroyed, in all cases, at a temperature just above 45° Centigrade (113° Fahrenheit). Even the enzymes or organic catalysts, which are essential for bio-chemical processes, are destroyed at a temperature between 60° and 70° Centigrade. This excludes the possibility of the contemporaneousness of protoplasm and inorganic matter, and points to a beginning of life in our solar system. Moreover, independently of this theory, the geologist sees in the primitive crystalline rocks (granites, diorites, basalts, etc.) and in the extant magmas of volcanoes evidences of an azoic age, during which temperatures incompatible with the survival of even the blue-green algæ or the most resistent bacterial spores must have prevailed over the surface of the globe. In fact, it is generally recognized by geologists that the igneous or pyrogenic rocks, which contain no fossils, preceded the sedimentary or fossiliferous rocks. The new *planetesimal hypothesis,* it is true, is said to be compatible with a cold origin of the universe. Nevertheless, this theory assumes a very gradual condensation of our cosmos out of dispersed gases and star dust, whereas life demands as the *sine qua non* condition of its existence a differentiated environment consisting of a lithosphere, a hydrosphere, and an atmosphere. Hence, it is clear that life did not originate until such an appropriate environment was an accomplished fact. All theories of cosmogony, therefore, point to a beginning of life subsequent to the constitution of the inorganic world.

Now, it is impossible for organic life to antecede itself. If, therefore, it has had a beginning in the world, it must have had a first active cause distinct from itself; and the active cause, in question, must, consequently, have been either something intrinsic, or something extrinsic, to inorganic matter. The hypothesis, however, of a spontaneous origin of life

through the agency of forces intrinsic to inorganic matter is scientifically untenable. Hence it follows that life originated through the action of an immaterial or spiritual agent, namely, God, seeing that there is no other assignable agency capable of bringing about the initial production of life from lifeless matter.

§ 9. Futile Evasions

Many and various are the efforts made to escape this issue. One group of scientists, for example, attempt to rid themselves of the difficulty by diverting our attention from the problem of a beginning of organic life in the universe to the problem of its translation to a new habitat. This legerdemain has resulted in the theories of *cosmozoa* or *panspermia,* according to which life originates in a favorable environment, not by reason of spontaneous generation, but by reason of importation from other worlds. This view has been presented in two forms: (1) the "meteorite" theory, which represents the older view held by Thomson and Helmholtz; (2) the more recent theory of "cosmic panspermia" advocated by Svante Arrhénius, with H. E. Richter and F. J. Cohn as precursors. Sir Wm. Thompson suggested that life might have been salvaged from the ruins of other worlds and carried to our own by means of meteorites or fragments thrown off from life-bearing planets that had been destroyed by a catastrophic collision. These meteorites discharged from bursting planets might carry germs to distant planets like the earth, causing them to become covered with vegetation. Against this theory stands the fatal objection that the transit of a meteorite from the nearest stellar system to our own would require an interval of 60,000,000 years. It is incredible that life could be maintained through such an enormous lapse of time. Even from the nearest planet to our earth the duration of the journey would be 150 years. Besides, meteorites are heated to incandescence while passing through the atmosphere, and any seeds they might contain would perish by reason of the

heat thus generated, not to speak of the terrific impact, which terminates the voyage of a meteorite.

Arrhénius suggests a method by which microörganisms might be conveyed through intersidereal space with far greater dispatch and without any mineral vehicle such as a meteorite. He notes that particles of cosmic dust leave the sun as a coronal atmosphere and are propelled through intervening space by the pressure of radiation until they reach the higher atmosphere of the earth (viz. at a height of 100 kilometers from the surface of the latter), where they become the electrically charged dust particles of polar auroras (*v.g.* the aurora borealis). The motor force, in this case, is the same as that which moves the vanes of a Crookes' radiometer. Lebedeff has verified Clerk-Maxwell's conceptions of this force and has demonstrated its reality by experiments. It is calculated that in the immediate vicinity of a luminous surface like that of the sun the pressure exerted by radiation upon an exposed surface would be nearly two milligrams per square centimeter. On a nontransparent particle having a diameter of 1.5 microns, the pressure of radiation would just counterbalance the force of universal gravitation, while on particles whose diameter was 0.16 of a micron, the pressure of radiation would be ten times as great as the pull of gravitation. Now bacterial spores having a diameter of 0.3 to 0.2 of a micron are known to bacteriologists, and the ultramicroscope reveals the presence of germs not more than 0.1 of a micron in size.[1] Hence it is con-

[1] Recently, by means of photography with short-length light waves, the bacteria of "Foot-and-mouth disease," invisible to the highest power microscope, have been revealed as rods about 100 submicrons (*i.e.* 0.1 micron, or 0.0001 millimeter) in length. (*cf. Science,* May 30, 1924, Supplement X.)

Germs of this dimension could be as easily transported by radiation as the alleged electrically charged stardust in the aurora borealis. It may be of interest, however, to note, in this connection, that the most recent theory of the aurora borealis discards stardust in favor of nitrogen snow. Lars Vegard, a Norwegian professor, ascribes the peculiar greenish tint in the Northern Lights to the action of solar radiations on nitrogen snow, which he assumes to exist at an altitude

ceivable that germs of such dimensions might be wafted to limits of our atmosphere, and might then be transported by the pressure of radiation to distant planets or stellar systems, provided, of course, they could escape to the germicidal action of oxidation, desiccation, ultra-violet rays, etc. Arrhénius calculates that their journey from the earth to Mars would, under such circumstances, occupy a period of only 20 days. Within 80 days they could reach Jupiter, and they might arrive at Neptune on the confines of our solar system after an interval of 3 weeks. The transit to the constellation of the Centaur, which contains the solar system nearest to our own (the one, namely, whose central sun is the star Alpha), would require 9,000 years.

Arrhénius' theory, however, that "life is an eternal rebeginning" explains nothing and leaves us precisely where we were. In the metaphysical as well as the scientific sense, it is an evasion and not a solution. To the logical necessity of putting an end to the retrogradation of the subalternate conditions, upon which the realities of the present depend for their actual existence, we have already adverted. Moreover, the reasons which induce the scientist to postulate a beginning of life in our world are not based on any distinctive peculiarity of that world, but are universally applicable, it being established by the testimony of the spectroscope that other worlds are not differently constituted than our own. Hence Schäfer voices the general attitude of scientific men when he says: "But the acceptance of such theories of the arrival of life on earth does not bring us any nearer to a conception of its actual mode of origin; on the contrary, it merely serves to banish the

of more than 60 miles above the earth. When he condensed crystals of solid nitrogen on a copper plate by freezing with liquid hydrogen, he found that these crystals, after bombardment with cathode rays, emit a light of green color, which gives the same strong green spectrum line as the spectrum of the aurora. As the solid nitrogen evaporates, it begins to emit the reddish light characteristic of nitrogen gas. This phenomenon would explain the changes of color that occur in the aurora borealis. (*cf. Science,* April 18, 1924, Suppl. X.)

investigation of the question to some conveniently inaccessible corner of the universe and leaves us in the unsatisfactory condition of affirming not only that we have no knowledge as to the mode of origin of life—which is unfortunately true—but that we never can acquire such knowledge—which it is to be hoped is not true. Knowing what we know, and believing what we believe, . . . we are, I think (without denying the possibility of the existence of life in other parts of the universe), justified in regarding these cosmic theories as inherently improbable." (Dundee Address of 1912, cf. Smithson. Inst. Rpt. for 1912, p. 503.)

Dismissing, therefore, all evasions of this sort, we may regard as scientifically established the conclusion that, so far as our knowledge goes, inorganic nature lacks the means of self-vivification, and that no inanimate matter can become living matter without first coming under the influence of matter previously alive. Given, therefore, that the conditions favorable to life did not always prevail in our cosmos, it follows that life had a beginning, for which we are obliged to account by some postulate other than abiogenesis. This conclusion seems inescapable for those who concede the scientific absurdity of spontaneous generation, but, by some weird freak of logic, not only is it escaped, but the very opposite conclusion is reached through reasoning, which the exponents are pleased to term philosophical, as distinguished from scientific, argumentation. The plight of these "hard-headed worshippers of fact," who plume themselves on their contempt for "metaphysics," is sad indeed. Worsted in the experimental field, they appeal the case from the court of facts to that aprioristic philosophy. "Physic of metaphysic begs defence, and metaphysic calls for aid on sense!"

Life, they contend, either had no beginning or it must have begun in our world as the product of spontaneous generation. But all the scientific theories of cosmogony exclude the former alternative. Consequently, not only is it not absurd to admit spontaneous generation, but, on the contrary, it is absurd not

to admit it. It is in this frame of mind that August Weismann is induced to confide to us "that spontaneous generation, in spite of all the vain attempts to demonstrate it, remains for me a logical necessity." ("Essays," p. 34, Poulton's Transl.) The presupposition latent in all such logic is, of course, the assumption that nothing but matter exists; for, if the possibility of the existence of a supermaterial agency is conceded, then obviously we are not compelled by *logical necessity* to ascribe the initial production of organic life to the exclusive agency of the physicochemical energies inherent in inorganic matter. Weismann should demonstrate his suppressed premise that matter coincides with reality and that spiritual is a synonym for nonexistent. Until such time as this unverified and unverifiable affirmation is substantiated, the philosophical proof for abiogenesis is not an argument at all, it is dogmatism pure and simple.

But, they protest, "To deny spontaneous generation is to proclaim a miracle" (Nägeli), and natural science cannot have recourse to "miracles" in explaining natural phenomena. For the "scientist," miracles are always absurd as contradicting the uniformity of nature, and to recur to them for the solution of a scientific problem is, to put it mildly, distinctly out of the question. Hence Haeckel regards spontaneous generation as more than demonstrated by the bare consideration that no alternative remains except the unspeakable scientific blasphemy implied in superstitious terms like "miracle," "creation," and "supernatural." For a "thinking man," the mere mention of these abhorrent words is, or ought to be, argument enough. "If we do not accept the hypothesis of spontaneous generation," Haeckel expostulates, "we must have recourse to the miracle of a *supernatural creation*." (Italics his—"History of Creation," I, p. 348, Lankester's Transl.) It would be a difficult matter, indeed, to cram more blunders into one short sentence! We will not, and need not, undertake to defend the supernatural here. Suffice it to say, that the initiation of life in inorganic matter by the Author

of Life would not be a creation, nor a miracle, nor a phenomenon pertaining to the supernatural order.

The principle of the minimum forbids us to postulate the superfluous, and a creative act would be superfluous in the production of the first organisms. Inorganic nature contains all the material elements found in living organisms, and all organisms, in fact, derive their matter from the inorganic world. If, therefore, they are thus dependent *in their continuance* upon a supply of matter administered by the inorganic world, it is to be presumed that they were likewise dependent on that source of matter *in their first origin.* In other words, the material substrata of the first organisms were not produced anew, but derived from the elements of the inorganic world. Hence they were not created, but formed out of preëxistent matter. A *creative* act would involve *total* production, and exclude the preëxistence of the constituent material under a different form. A *formative* act, on the contrary, is a *partial* production, which presupposes the material *out of which* a given thing is to be made. Hence the Divine act, whereby organic life was first educed from the passive potentiality of inorganic matter, was formative and not creative. Elements preëxistent in the inorganic world were combined and intrinsically modified by impressing upon them a new specification, which raised them in the entitive and dynamic scale, and integrated them into units capable of self-regulation and reflexive action. This modification, however, was intrinsic to the matter involved and nothing was injected into matter from without. Obviously, therefore, the production of the first organisms was not a creation, but a formation.

Still less was it a miracle; for a miracle is a visible interposition in the course of nature by a power superior to the powers of nature. A given effect, therefore, is termed miraculous with express reference to some existing natural agency, whose efficacy it, in some way, exceeds. If there existed in inorganic nature some natural process of self-vivification, then any Divine interposition to produce life independently

of this natural agency, would be a miraculous intervention. As a matter of fact, however, inorganic nature is destitute of this power of self-vitalization, and consequently no natural agency was superseded or overridden by the initial imparting of life to lifeless matter. Life was not ordained to originate in any other way. Given, therefore, this impotence of inorganic nature, it follows that an initial vivification of matter by Divine power was demanded by the very nature of things. The Divine action did not come into competition, as it were, with existing natural agencies, but was put forth in response to the exigencies of nature itself. It cannot, therefore, be regarded as miraculous.

Nor, finally, is there any warrant for regarding such an initial vivification of matter as supernatural. Only that is supernatural which transcends the nature, powers, and exigencies of all things created or creatable. But, as we have seen, if life was to exist at all, a primal animation of inanimate matter by Divine power was demanded by the very nature of things. Here the Divine action put forth in response to an exigency of nature and terminated in the constitution of living nature itself. Now, the effect of a Divine action, by which the natures of things are initially constituted, plainly pertains to the order of nature, and has nothing to do with the supernatural. Hence the primordial constitution by Divine power of living nature was not a supernatural, but a purely natural, event.

CHAPTER II

THE ORIGIN OF THE HUMAN SOUL

§ 1. Matter and Spirit

We live in an age in which scientific specialization is stressed as the most important means of advancing the interests of human knowledge; and specialism, by reason of its many triumphs, seems to have deserved, in large measure, the prestige which it now enjoys. It has, however, the distinct disadvantage of fostering provincialism and separatism. This lopsided learning of the single track mind is a condition that verges on paranoia, leads to naïve contempt for all knowledge not reducible to its own set of formulæ, and portends, in the near future, a Babel-like confusion of tongues. In fact, the need of a corrective is beginning to be felt in many quarters. This corrective can be none other than the general and synthetic science of philosophy; it is philosophy alone that can furnish a common ground and break down the barriers of exclusiveness which immure the special sciences within the minds of experts.

Scientists readily admit the advantage of philosophy in theory, but in practice their approval is far from being unqualified. A subservient philosophy, which accepts without hesitation all the current dogmas of contemporary science, is one thing, and a critical philosophy venturing to apply the canons of logic to so-called scientific proof is quite another. Philosophy of the latter type is promptly informed that it has no right to any opinion whatever, and that only the scientific specialist is qualified to speak on such subjects. But the disqualification, which is supposed to arise from lack of special knowledge, is just as promptly forgotten, when there is

question of philosophy in the rôle of a pliant sycophant, and the works of a Wells or a van Loon are lauded to the skies, despite the glaring examples of scientific inaccuracy and ignorance, in which they abound.

This partiality is sometimes carried to a degree that makes it perfectly preposterous. Thus it is by no means an infrequent thing to find scientists dismissing, as unworthy of a hearing, a philosopher like Hans Driesch, who spent the major portion of his life in biological research, and combined the technical discipline of a scientist with the mental discipline of a logician. The chemist, H. E. Armstrong, for instance, sees in the mere label "philosopher" a sufficient reason for barring his testimony. "Philosophers," jeers the chemist, with flippant irrelevance, "must go to school and study in the purlieus of experimental science, if they desire to speak with authority on these matters." (Smithson. Inst. Rpt. for 1912, p. 528.) Such is his comment on Driesch, yet Driesch did nothing at all, if he did not do far more than Armstrong prescribes as a prerequisite for authoritative speaking. In James Harvey Robinson, on the contrary, we have an example of the tendency of scientists to coddle philosophers who assume a docile, deferential, and submissive attitude towards every generalization propounded in the name of natural science. In sheer gratitude for his uncritical acquiescence, his incapacitation as a nonspecialist is considerately overlooked, and he can confess, without the slightest danger of discrediting his own utterances: "I am not . . . a biologist or palæontologist. But I have had the privilege of consorting familiarly with some of the very best representatives of those who have devoted their lives to the patient study of the matters involved in this controversy. I think I quite understand their attitude." (*Harper's Magazine,* June, 1922, p. 68.) By his own testimony he is a scientific amateur, but this does not, in the least, prevent him from "speaking with authority" or from being lionized in scientific circles as an evolutionary "defender of the faith." Clearly, it is the nature of their respective views, and not the

possession or absence of technical knowledge, which makes Robinson a favorite, and Driesch a *persona non grata,* with "the very best representatives" of contemporary science. "Science," says a writer in the *Atlantic Monthly* (Oct., 1915), "has turned all philosophy out of doors except that which clings to its skirts; it has thrown contempt on all learning that does not depend upon it; and it has bribed the sketches by giving us immense material comforts."

Here, however, we are concerned with the fact, rather than the justice, of this discrimination which the scientific world makes between philosopher and philosopher. Certain it is that Robinson has received no end of encomiums from scientists, who apparently lack the literary gifts to expound their own philosophy, and that his claim to represent the views of a large and influential section of the scientific world is, in all probability, entirely correct. It is this manifest approval of scientific men which lends especial interest to the remarks of this scientific dilettante, and we shall quote them as expressing the prevalent scientific view on the origin of man, a view which, with but slight variations, has persisted from the time of Darwin down to the present day.

"The recognition," says Robinson, "that mankind is a species of animal, is, like other important discoveries, illuminating." (*Science,* July 28, 1922, p. 74.) To refer to the recognition of man's animality as a *discovery* is a conceit too stupid for mere words to castigate. Surely, there was no need of the profound research or delicate precision of modern science to detect the all too obvious similarity existing between man and beast. Mankind did not have to await the advent of an "enlightened" nineteenth, or twentieth century to be assured of the truth of a commonplace so trite and palpable. Even the "benighted" scholastics of medieval infamy had wit enough to define man as a rational animal. Indeed, it would be a libel on human intelligence to suppose that anyone, in the whole history of human thought, was ever sufficiently fatuous to dispute the patent fact that man is a sentient or-

ganism compounded of flesh, blood, bone, and sinew like the brute. The "discovery" that man is a species of animal dates from the year one of human existence, and it is now high time for the novelty of this discovery to be worn off.

Even as a difficulty against human superiority and immortality, the "recognition" is by no means recent. We find it squarely faced in a book of the Old Testament, the entire book being devoted to the solution of the difficulty in question. "I said in my heart concerning the estate of the sons of men . . . that they might see they are themselves beasts. For that which befalleth the sons of men befalleth beasts; even one thing befalleth them; as the one dieth so dieth the other; yea, they have all one breath; so that man hath no preeminence above a beast; for all is vanity. All go unto one place; all are of the dust, and all return to dust. Who knoweth the spirit of man whether it goeth upward, and the spirit of the beast whether it goeth downward to the earth?" (*Ecclesiastes*, III: 18-21.) The sacred writer insists that, so far as the body is concerned, man and the brute stand on the same level; but what of the human soul? Is it, he asks, resolvable into matter like the soul of a beast, or is it a supermaterial principle destined, not for time, but for eternity? At the close of the book, the conclusion is reached that the latter alternative is the true solution of the riddle of human nature—"the dust returneth to the earth whence it was, and the spirit returneth to God who gave it." (Ch. XII, v. 7.)

Centuries, therefore, before the Christian era, this problem was formulated by Ecclesiastes, the Jew, and also, as we shall presently see, by Aristotle, the coryphæus of Greek philosophy. Nay, from time immemorial man, contrasting his aspirations after immortality with the spectacle of corporal death, has appreciated to the full the significance of his own animality. Never was there question of whether man is, or is not, just as thoroughly an animal as any beast, but rather of whether, his animal nature being unhesitatingly conceded, we are not, none the less, forced to recognize in him, over and above this,

the existence of a spiritual mind or soul, differentiating him from the brute and constituting him a being unique, despite the unmistakable homologies discernible between bestial organisms and the human body. Everywhere and always mankind as a whole have manifested, by the universal and uniquely human practice of burying the dead, their unswerving and indomitable conviction that man is spirit as well as flesh, an animal, indeed, yet animated by something not present in the animal, namely, a spiritual soul, deathless and indestructible, capable of surviving the decay of the organism and of persisting throughout eternity.

But, if the human mind or soul is spiritual, it is clear that it cannot be a product of organic evolution, any more than it can be a product of parental generation. On the contrary, each and every human soul must be an immediate creation of the Author of Nature, not evolved from the internal potentiality of matter, but infused into matter from without. The human soul is created in organized matter, but not from it. Nor can the Divine action, in this case, be regarded as a supernatural interposition; for it supplements, rather than supersedes, the natural process of reproduction; and, since it is not *in* matter to produce spirit, a creative act is demanded by the very nature of things.

Evolution is nothing more nor less than a transmutation of matter, and a transmutation of matter cannot terminate in the annihilation of matter and the constitution of non-matter or spirit. If nothing of the *terminus a quo* persists in the final product, we have substitution, and not transmutation. The evolution of matter, therefore, cannot progress to a point where all materiality is eliminated. Hence, whatever proceeds from matter, either as an emanation or an action, will, of necessity, be material. It should be noted, however, that by material we do not mean corporeal; for material denotes not merely matter itself, but everything that intrinsically depends on matter. The term, therefore, is wider in its sense than corporeal, because it comprises, besides matter, all the prop-

erties, energies, and activities of matter. Hence whatever is incapable of existence and activity apart from matter (whether ponderable or imponderable) belongs to the material, as distinguished from the spiritual, order of things. The soul of a brute, for example, is not matter, but it is material, nevertheless, because it is totally dependent on the matter of the organism, apart from which it has neither existence nor activity of its own.

In the constitution of the sentient or animal soul, matter reaches the *culmination of its passive evolution.* True, its inherent physicochemical forces do not suffice to bring about this consummation, wherewith its internal potentiality is exhausted. Nevertheless, the emergence of an animal soul from matter is conceivable, given an agency competent to educe it from the intrinsic potentiality of matter; for, in the last analysis, the animal soul is simply an internal modification of matter itself. But, if spirit is that which exists, or is, at least, capable of existence, apart from matter, it goes without saying that spirit is neither *derivable* from, nor *resolvable* into, matter of any kind. Consequently, it cannot be evolved from matter, but must be produced in matter by creation (*i.e.* total production). *To make the human mind or soul a product of evolution is equivalent to a denial of its spirituality,* because it implies that the human soul like that of the brute, is inherent in the potentiality of matter, and is therefore a purely material principle, totally dependent on the matter, of which it is a perfection. Between such a soul and the sentient principle present in the beast, there would be no essential difference of kind, but only an accidental difference of degree; and this is precisely what Darwin and his successors have spared no effort to demonstrate. James Harvey Robinson is refreshingly frank on this subject, and we will therefore let him be spokesman for those who are more reticent:

"It is the extraordinarily illuminating discovery (*sic*) of man's animalhood rather than evolution in general that

troubles the routine mind. Many are willing to admit that it looks as if life had developed on the earth slowly, in successive stages; this they can regard as a merely curious fact and of no great moment if only man can be defended as an honorable exception. The fact that we have an animal body may also be conceded, but surely man must have a soul and a mind altogether distinct and unique from the very beginning bestowed on him by the Creator and setting him off an immeasurable distance from any mere animal. But whatever may be the religious and poetic significance of this compromise it is becoming less and less tenable as a scientific and historic truth. The *facts* indicate that man's *mind* is quite as clearly of animal extraction as his body." (*Science*, July 28, 1922, p. 95—italics his.)

This language has, at least, the merit of being unambiguous, and leaves us in no uncertainty as to where the writer stands. It discloses, likewise, the animus which motivates his peculiar interest in transformistic theories. If evolution were incapable of being exploited in behalf of materialistic philosophy, Mr. Robinson, we may be sure, would soon lose interest in the theory, and would once more align himself with the company, which he has so inappropriately deserted, namely, "the routine minds" that regard evolution "as a merely curious fact of no great moment." Be that as it may, his final appeal is to the "facts," and it is to the facts, accordingly, that we shall go; but they will not be the irrelevant "facts" of anatomy, physiology, and palæontology. Sciences such as these confine their attention to the external manifestations of human life, and can tell us nothing of man's inner consciousness. It does not, therefore, devolve upon them to pronounce final judgment upon the origin of *man*. For that which is the distinguishing characteristic of man is not his animal nature, that he shares in common with the brute, but his rational nature, which alone differentiates him from "a beast that wants discourse of reason." We cannot settle the question as to whether or not man's *mind* is "of animal extraction" by comparing his *body*

with the bodies of irrational vertebrates. To institute the requisite comparison between the rational mentality of man and the purely sentient consciousness of irrational animals falls within the exclusive competence of psychology, which studies the internal manifestations of life as they are presented to the intuition of consciousness, rather than biology, which studies life according to such of its manifestations as are perceptible to the external senses. Hence it is within the domain of psychology alone, that man can be studied on his distinctively human, or rational, side, and it is to this science, accordingly, that we must turn in our search for facts that are germane to the problem of the origin of man and the genesis of the human mind. How little, indeed, does he know of human nature, whose knowledge of it is confined to man's insignificant anatomy and biology, and who knows nothing of the triumphs of human genius in literature, art, science, architecture, music, and a thousand other fields! Psychology alone can evaluate these marvels, and no other science can be of like assistance in solving the problem of whether man is, or is not, unique among all his fellows of the animal kingdom.

§ 2. The Science of the Soul

As a distinct science, psychology owes its origin to Aristotle, whose *"Peri Psyches"* is, in all probability, the first formal treatise on the subject. Through his father, Nichomachus, who was court physician to Philip of Macedon, he became acquainted, at an early age, with biological lore in the form of such medical botany, anatomy, and physiology as were commonly known in prescientific days. Subsequently, his celebrated pupil, Alexander the Great, placed at his disposal a vast library, together with extensive opportunities for biological research. This enabled the philosopher to criticize and summarize the observations and speculations of his predecessors in the field, and to improve upon them by means of personal reflection and research. In writing his psychology, he was naturally forced to proceed on the basis of the facts dis-

coverable by internal experience (introspection) and unaided external observation. Of such facts as are only accessible by means of instrumentation and systematic experimentation, he could, of course, know nothing, since their exploration awaited the advent of modern mechanical and optical inventions. But the factual foundation of his treatise, though not extensive, was solid, so far as it went, and his selection, analysis, and evaluation of the materials at hand was so accurate and judicious, that the broad outlines of his system have been vindicated by the test of time, and all the results of modern experimental research fit, with surprising facility, into the framework of his generalizations, revision being nowhere necessary save in nonessentials and minor details. Wilhelm Wundt, the Father of Experimental Psychology, pays him the following tribute: "The results of my labors do not square with the materialistic hypothesis, nor do they with the dualism of Plato or Descartes. It is only the animism of Aristotle which, by combining psychology with biology, results as a plausible metaphysical conclusion from Experimental Psychology." ("Grundzüge der physiologischen Psychologie," 4te Auflage, II, C. 23, S. 633.)

Literally translated, the title of Aristotle's work signifies a *treatise concerning the soul.* It set a precedent for the scholastic doctors of the thirteenth century, and *de anima* became with them a technical designation for all works dealing with this theme. In the sixteenth century the selfsame usage was embalmed in the Greek term psychology, which was coined with a view to rendering the elliptic Latin title by means of a single word. Melanchthon is credited with having originated the term, which, in its original use as well as its etymology, denoted a science of the *psyche* or soul.

Towards the close of the seventeenth century, however, the meaning of the term in question began to undergo a marvelous evolution, of which the end is not yet. The process was initiated by Descartes, under whose auspices psychology was changed from a science of the *soul* into a science of the *mind.*

Then, under the influence of Hume and Kant, the *noumenal mind* disappeared, leaving only *phenomenal consciousness.* Recently, with the advent of Watson, even consciousness itself has been discarded and psychology has become a science of *behavior.* And here, for the time being, at any rate, the process has come to a stop, just one step short of complete nihilism. Woodworth quotes the following waggish comment: "First psychology lost its soul, then it lost its mind, then it lost consciousness; it still has behavior of a kind." ("Psychology, the Science of Mental Life," p. 2, footnote.) This gradual degeneration of psychology from animism into behaviorism is one of the greatest ironies in the history of human thought. All of this, however, was latent in the corrosive Cartesian principle of "scientific doubt." *Facilis descensus Averni!* It is easy to question the validity of this or that kind of human knowledge, but difficult to arrest, or even foresee, the consequences which the remorseless logic of scepticism portends.

Disintegration set in, as has been said, when Descartes substituted his *psychophysical dualism* of *mind* and *matter* for Aristotle's *hylomorphic dualism* of *soul* and *body.* The French philosopher, in an appendix to his "Meditations," which dates from 1670, expressly rejects the Aristotelian term of soul or *psyche,* and announces his preference for mind or spirit, in the following words: "The substance in which thought immediately resides is here called mind (mens, esprit). I here speak, however, of mens (mind) rather than anima (soul), for the latter is equivocal, being frequently applied to denote what is material" ("Reply to the Second Objections," p. 86). Henceforth psychology ceased to be a science of the soul, and became, instead, a science of the mind.

Descartes, one must bear in mind, divided the universe into two great realms of being, namely: the conscious and the unconscious, the *psychic* world of mind and the *physical* world of matter, unextended substance which thinks and extended substance which moves. In man these two substantial principles were conceived as being united by the tenuous link

of mere contact, the spirit or mind remaining separate from, and unmingled with, its material partner, the body. The main trouble with this dualism is that it draws the line of demarcation at the wrong place. Reason and sense-consciousness are bracketed together above the line as being equally spiritual; physiological processes and processes purely physicochemical are coupled below the line as being equally mechanical. Now, when a brain-function such as sense-perception is introduced, like another Trojan Horse, into the citadel of spiritualism, it is a comparatively easy task for materialism to storm and sack that citadel by demonstrating with a thousand neuro-physiological facts that all sensory functions are rigidly correlated with neurological processes, that they are, in short, functions of the nervous system, and therefore purely material in nature. On the other hand, once we retreat from the trench of distinction between the processes of unconscious or vegetative life and the physicochemical processes of the inorganic world, that moment we have lost the strategic position in the conflict with mechanism, and nothing avails to stay its triumphant onrush. Hence, from first to last, it is perfectly clear that the treacherous psychophysical dualism of Descartes has done far more harm to the cause of spiritualism than all the assaults of materialism. There is a Latin maxim which says: *Extrema sese tangunt*—"Extremes come in contact with each other." The ultraspiritualism of Descartes by confounding spiritual, with organic consciousness, leads by the most direct route to the opposite extreme of crass materialism.

Aristotle's dualism of matter and form, which is but a physical application of his transcendental dualism of potency (*dynamis*) and act (*entelechy*), is very different from the Cartesian dualism of the physical and the psychic. According to the Aristotelian view, as we have seen in the last chapter, all the physical entities or substantial units of nature (both living and inorganic) are fundamentally *dual* in their essence, each consisting of a definitive principle called entelechy and

a plastic principle called matter. Entelechy is the integrating determinant, the source of the unit's coherence and of its differentiation from units of another type. Matter is the determinable and quantifying factor, in virtue of which the unit is potentially-multiple and endowed with mass. In the electrochemical reactions of non-living substances (synthesis, analysis, and transmutation), entelechy is the variant and matter is the constant; in the metabolic activities of living substances (assimilation and dissimilation), matter is the variant and entelechy is the constant. This persistent entelechy of the living unit or organism is what Aristotle terms the *psyche* or soul. The latter, therefore, may be defined as the vital principle or primary source of life in the organism.

But in using such terms as "soul" and "vital principle" we are employing expressions against which not merely rabid mechanists, but many conservative biologists as well, see fit to protest. The opposition of the latter, however, is found on closer scrutiny to be *nominal* rather than *real.* It is the *name* which offends; they have no objection to the *thing signified.* Wilson, to cite a pertinent example, rejects as meaningless all such terms as "vital principle," "soul," etc. "They are words," he avers, "that have been written into certain spaces that are otherwise blank in our record of knowledge, and as far as I can see no more than this." ("Biology," p. 23, 1908.) Yet he himself affirms again and again the existence of the reality which these terms (understood in their Aristotelian sense) denote. In discussing the relation of the tissue cell to the multicellular body, for instance, he speaks of "a formative power pervading the growing mass as a whole." ("The Cell," 2nd ed., p. 59), and, in his recent lecture on the "Physical Basis of Life," he makes allusion to "the integrating and unifying principle in the vital processes." (*Science,* March 9, 1923, p. 284.) It would seem, therefore, that Wilson's aversion to such terms as soul and vital principle is based on the *dynamic* sense assigned to them by the neo-vitalists, who, as we have seen, regard the vital principle

as a force *sui generis* or a *unique agent,* which operates intrusively among physicochemical factors in the rôle of an active or efficient cause of vital functions. That such is really the case, appears from his rhetorical question: "Shall we then join hands with the neo-vitalists in referring the unifying and regulatory principle to the *operation* of an unknown power, a directive *force,* an archæus, an entelechy or a soul?" (*Loc. cit.,* p. 285—italics mine.) The objection, however, does not apply to these terms used in their Aristotelian sense. In the philosophy of the Stagirite, the soul, like all other entelechies, is a cause in the *entitive,* but not in the *dynamic,* order of things. Its efficacy is *formal,* not *efficient.* It is not an agent, but a specifying type. The organism must be integrated, specified, and existent *before* it can operate, and hence its integration and specification by the soul is prior to all vital activity. The soul is a constituent of being and not an immediate principle of action. The soul is not even an entity (in the sense of a complete and separate being), but rather an incomplete entity or constituent of an entity. It takes a complete entity to be an agent, and the soul or vital entelechy is not an independent existent, which is somehow inserted into the organism, but an incomplete being which has no existence of its own, but only coexistence, in the composite that it forms with the organism. Nor is there any such thing as a special vital force resident in the organism. The executive factors in all vital operations of the organic order are the physicochemical energies, which are native to matter in general. These forces, as we have seen, receive a reflexive orientation and are elevated to a higher plane of efficiency by reason of their association with an entelechy superior to the binding and type-determining principles present in inorganic units, but they are not supplanted or superseded by a new executive force. Wilson's fear, therefore, that the experimental analysis of life is discouraged by vitalism, inasmuch as this conception *subtracts something from the efficiency of the physicochemical forces,* is groundless in the case of hylomorphic vitalism, but is well-founded in the

case of such systems as the neo-vitalism of Driesch and the spiritualism of Descartes.

Summing up, therefore, we may say that the soul, like other entelechies, is consubstantial with its material substrate, the body. True it is more autonomous than are the inflexible entelechies of inorganic nature, inasmuch as it is independent of any given atom, molecule, or cell in the organic aggregate. Such a degree of freedom, for example, is not possessed by the most complex molecules, which show no other flexibility than tautomerism, even this small readjustment involving a change in their specificity. But this autonomy does not preclude the essential dependence of the soul upon the body. Generally speaking, the soul is incapable of existence apart from its total substrate, the organism. We say, *generally speaking*, because, as previously intimated, an exception must be made in the case of the *human soul*, which, being, as we shall see, a self-subsistent and spiritual entelechy, is by itself, apart from its material substrate, a sufficient subject of existence, and is therefore capable of surviving the dissolution of its complementary principle, the organism. Nevertheless, even in man, the soul forms one substance with the organism, and the organism participates as a coëfficient factor in all his vital functions, both physiological and psychic, excluding only the *superorganic* or *spiritual* functions of rational thought and volition, whose agent and recipient is the *soul alone*. In man, then, soul and body unite to form a single substance, a single nature, and a single person. Apart from the body, the human soul is, indeed, a complete entity, in the sense that it is capable of subsistence (independent existence), but, in another sense, it is not a complete entity, because apart from the body it cannot constitute a complete nature or complete personality. It is this essential incompleteness of the discarnate human soul that forms the natural basis of the Christian doctrine of the Resurrection of the Dead.

Here, however, it is important to note the difference between the hylomorphic spiritualism of Aristotle and the psy-

chophysical spiritualism of Descartes. By the latter *all* conscious or physic functions are regarded as spiritual. The former, however, recognizes the fundamental difference which exists between the lower or animal, and the higher or rational functions of our conscious life. Sense-perception and sensual emotion belong to the former class, and must be regarded as *organic* functions, whose agent and subject is neither the soul alone nor the organism alone, but the soul-informed organism or substantial composite of body and soul. Rational thinking and willing, on the contrary, are classified as *superorganic* or *spiritual* functions, inasmuch as they exclude the coägency of the organism and have the soul alone for their active cause and receptive subject.

The soul, in fine, is the formal principle or primary source of the threefold life in man, namely, the metabolic life, which man shares with plants, the sentient life, which he shares with animals, and the rational life, which is uniquely human. The human soul is often spoken of as the mind. In their dictionary sense, both terms denote one and the same reality, namely, the human entelechy or vital principle in man, but the connotation of these terms is different. The term soul signifies the vital principle in so far as it is the primary source of every kind of life in man, that is, vegetative, sentient, and rational. The term mind, however, connoting conscious rather than unconscious life, signifies the vital principle in so far as it is the root and ground of our conscious life (both sentient and rational). Here, however, the distinction is of no great moment, and the terms may be regarded as synonymous. The definitions which we have given are, of course, blasphemous in the ears of our modern neo-Kantian phenomenalists, whose preference is for a *functional*, rather than a *substantial*, mind or soul; but we will pay our respects to them later.

It is clear, however, from what has been said, that, for evidences of the superiority and spirituality of the human soul, we must recur, not to the external manifestations of our nutritive life, but to the internal manifestations of our conscious

life. The latter are wholly inaccessible to the external senses and perceptible only to the intuition of consciousness, introspection, or internal experience, as it is variously called. All our self-knowledge rests on the basis of introspection, and without it the science of psychology would be impossible. In fact, not only psychology, but the physical sciences as well, depend for their validity on the testimony of consciousness; for the external world is only knowable to the extent that it enters the domain of our consciousness. Recently, as we have seen, a tendency to discredit internal experience has arisen among materialistic extremists. This "tendency," to quote the words of Keyser, "most notably represented by the behaviorist school of psychologists (like Professor Watson, for example), is manifest in the distrust of introspections as a means of knowledge of mental phenomena and in the growing dependence of psychology upon external observation of animal and human behavior and upon physiological experiment, as if matter were regarded 'as something much more solid and indubitable than mind' (Bertrand Russell)."—C. J. Keyser, *Science*, Nov. 25, 1921, p. 520. Since, however, all our knowledge depends on the validity of consciousness, such a tendency is suicidal and destructive of all science, whether physical or psychological. The attempts, therefore, of mechanists, like Loeb, and behaviorists, like Watson, to dispense with consciousness overreach themselves. For how can the mechanists *know* that there are such things as tropisms, tactisms, or reaction-systems, how can the behaviorist *study* such things as "situations," "adjustments," and S-R-bonds, how can the materialist *become aware* of the existence of molecules and atoms, except through the medium of their own conscious or psychic states? States of matter can be known only by means of states of mind, and the former, therefore, cannot be any more real than the latter. "What, after all," asks Cardinal Mercier, "is a fact of nature if the mind has not seized, examined, and assimilated it? True, the information of consciousness is often precarious. For this reason we do well to

aid and control it by scientific apparatus. These apparatus, however, can only aid, never supplant, introspection. The telescope does not replace the eye, but extends its vision." ("Relation of Exp. Psych. to Philosophy," pp. 40, 41—Trans. of Wirth.)

§ 3. The Nature of the Human Soul

Now our inner consciousness bears unmistakable witness to the existence within us of an abiding subject of our thoughts, feelings, and desires. In biology, the soul is revealed to us as a binding-principle, that obstructs dissolution of the organism, and a persistent type that maintains its identity amid an incessant flux of matter and flow of energy. Clearer still is testimony of introspective psychology, which reveals all our psychic activities and states as successive modifications of this permanent "I," "self," "personality," or "mind," according as we choose to express it. Human language proves this most forcibly; for the intramental facts and data of our conscious life simply cannot be so much as intelligibly expressed, much less, defined, or differentiated from the extramental facts of the physical world, without using terms that include a reference to this selfsame persistent subject of thought, feeling, and volition. Even inveterate phenomenalists, like Wundt, James, and Titchener, are obliged to submit to this inexorable linguistic law, in common with their unscientific brethren, the generality of mankind, although they do so only after futile attempts at a "scientific revision" of grammar, and with much grumbling over the "barbarous conceptions" of the gross-headed aborigines who invented human language. Be that as it may, no formulation of mental facts is possible except in terms that either denote or connote this permanent source and ground of human thought and feeling, as is apparent, for example, from such phrases as: *"I* think," *"I* wish," *"I* hear"; *"mental* states" (*i.e.* of the mind); *psychic* functions (*i.e.* of the psyche); *subjective* idealism (*i.e.* of the subject); a *conscious* act (from *con-scire:* "to know along with," because in

conscious acts the subject is known along with the object). The phenomenalists occasionally succeed, in their "most precise" passages, in omitting to mention the person, knower, or thinker behind thought, but they do so only at the cost of substituting *personal pronouns*, and of thus bringing back through the window what they have just ejected by way of the door. Our consciousness, therefore, makes us invincibly aware of the *existence* of a superficially variable, but radically unchangeable, subject of our mental life. It does not, however, tell us anything concerning the *nature* of this primary ground of thought, whether, for example, it is identical with the cerebral cortex, or something distinct therefrom, whether it is phenomenal or substantial, dynamic or entitive, spiritual or material. To decide these questions the unanalyzed factual data of internal experience do not suffice, but they do suffice to establish the reality of the ego or subject of thought. Later we shall see that the analysis of these data, when taken in conjunction with other facts, forces us to predicate of the soul such attributes as substantiality, simplicity, and spirituality, but here they are cited solely for their factual force and not for their logical implications.

The phenomenalistic schools of Interactionism and Psychophysical Parallelism deny the *substantiality* of the soul, and seek to resolve it into sourceless and subjectless processes. A phenomenal mind or soul, however, could not be the primary ground of mental life, for the simple reason that phenomena presuppose a supporting medium (otherwise they would be self-maintaining, and therefore, substantial). Now that which presupposes cannot be a primary principle, but only a secondary, or tertiary principle. Consequently, a functional mind could not be the primary and irreducible ground of mental life, but only that *of which* it is a function, whether that something is a material, or a spiritual substance. For the present, we are not interested in the nature of this ultimate substrate, we are content with the fact that it really exists. Phenomenalists (like Wundt, Paulsen, and James) are very inconsistent

when they admit material molecules as the extended substrate of extramental or physical phenomena, while denying the existence of the mind or ego as the inextended substrate of intramental or psychic phenomena. All substance, whether material or spiritual, is inaccessible to the senses. Even material substrates are manifested only by their phenomena, being in themselves supersensible and "metaphysical." If, then, the human understanding is inerrant in ascribing a material substrate to extramental phenomena, then it is equally inerrant in attributing to intramental phenomena the intimate substrate called mind, whether this substrate be a spiritual substance, or a material substance like the substrate of physical phenomena and that of organic life. As a matter of fact, the Psychophysical Parallelists actually do reduce mental phenomena to a material substrate (viz. the cerebral cortex). Their phenomenalism, which we will refute presently, is but a disingenuous attempt to gloss over their fundamental materialism. At all events, they are willing to admit an ultimate substantial ground of thought and volition, provided it is not claimed that this substrate is of a spiritual nature. The *bare existence* of some substrate, however, is all that we assert, for the present.

Before leaving this topic, we wish to call attention to the fact that the subject of thought and desire is *active* as well as *passive*. Mind, in other words, is not merely a persistent medium wherein passive mental states are maintained, but an active and synthetic principle as well. Mental processes, like those of judgment, reasoning, and recognition, require a unitary and unifying principle, which actively examines and compares our impressions and thoughts, in order to discern their relations to one another and to itself. Materialistic psychology, in spite of the plain testimony of consciousness, is all for ignoring the mind in its *active rôle* as the percipient of the identities and discrepancies of thought, and for regarding mind as a mere complex of mental states or transient flux of fleeting imagery. It is well, then, to bear in mind the indubitable

facts of internal experience, to which Cardinal Mercier calls attention. "English psychology," he observes, "had attempted a kind of anatomy of consciousness. It made all consist in passive sensations or impressions. These impressions came together, fused, dissociated under the guidance of certain laws, principally those of similarity and dissimilarity. The whole process was entirely passive without the intervention of any active subject. It was psychology without a soul. Now that things are being examined a little more closely, psychologists find that there are a lot of conscious states that are without the slightest doubt active on the part of the subject. There are a number of mental states upon which the subject brings his *attention* to bear, and attention (from *ad-tendere*) means activity. Ordinarily we do not know the intensity of a sensation without *comparing* it with another preceding one. This work of comparison, or, as the English call it, discrimination, is necessarily *activity*. The Associationists had confounded the fact of coëxistence with the perception of similarity or dissimilarity. Supposing even that the coëxistence of two mental states were entirely passive, it still remains true that the notion of their similarity or dissimilarity requires an *act of perception*. It is absolutely impossible to conceive psychical life without an *active subject* which *perceives* itself as living, *notes* the impressions it receives, *compares* its acts, *associates* and *dissociates* them; in a word, there can be no psychology without a perceiving subject which psychologists call *esprit*, or with the English, 'mind.'" (*Op. cit.*, pp. 52-54—italics his.)

The conflict between phenomenalism and the clear testimony of consciousness is summed up in the following words of T. Fontaine: "If all things are phenomena, then we ourselves can be nothing more than events unknown to one another; in order, then, that such events may appear to us united, so that we may be able to declare their succession within us, it is necessary that something else besides them should exist; and this something else, this link that binds them together, this principle that is conscious of their succession, can be

nothing else than a non-event or non-phenomenon, namely, a substance, an ego substantially distinct from sensations." ("La sensation et la pensée," p. 23.)

For the phenomenalists, mind is but a collective term for the phenomenal series of our transitory thoughts and feelings. With Wundt, they discard the substantial or entitive soul for a dynamic or functional one, *"die aktuelle Seele."* (Cf. Grundz. der Phys. Psych., ed. 5th, III, p. 758 *et seq.*) Thought antecedes itself by becoming its own thinker; for Titchener tells us: "The passing thought would seem to be the thinker." ("Pr. of Psych.," I, p. 342.) We do not think, but thought thinks; John does not walk, but walking walks; aeroplanes do not fly, but flight flies; air does not vibrate, but vibration vibrates. The phenomenalist *objectivates his subjective abstractions*, divorces processes from their agents, and substantializes phenomena. The source of his error is a confusion of the ideal, with the real, order of things. Because it is possible for us *to consider* a thought apart from any determinate thinker, by means of a mental abstraction, he very falsely concludes that it is possible for a thought *to exist* without a concrete thinker. It would be obviously absurd to suppose that the so-called Grignard reaction could occur without definite reactants, merely because we can think of it without specifying any particular kind of *alkyl halide;* it would be preposterous to infer, from the fact that vibration can be considered independently of any concrete medium such as air, water, or ether, that therefore a pure vibration can exist without any vibrating medium; and it is equally absurd to project an abstraction like subjectless thought into the realm of existent reality. Abstractions are ideal entities of the mind; they can have no real existence outside the domain of thought. Hence to assign a real or extralogical existence to actions, modalities, and properties, in isolation from the concrete subjects, to which they belong, is a procedure that is not legitimate in any other world than Alice's Wonderland, where, we are told, the Cheshire Cat left behind his notorious grin long

after his benign countenance had faded from view. His faceless grin is a fitting comment on the neo-Kantian folly of those who, as L. Chiesa says, "speak of phenomena without substance, of sensations without subject, of thoughts without the Ego, to which they belong, imitating in this way the poets, who personify honor, virtue, beauty, etc. Now all this proceeds exclusively from a confusion of the subjective abstraction with the reality, and from the assumption that the phenomenon, for example, exists without substance, because we are able (by means of abstraction) to consider the former independently of the latter." ("La Base del Realismo," p. 39.) In other words, the mind is capable of separating (representatively, of course, and not physically) its own phenomena from itself, but this is no warrant for transferring the abstractions thus formed from the ideal, to the real, order of things.

So much for the soul's substantiality, but it is a *simple*, as well as a substantial, principle, that is to say, it is inextended, uncompounded, incorporeal, and not dispersed into quantitative parts or particles. In other words, it is not a composite of constituent elements or complex of integral parts, but something really distinct from the body and pertaining to a different order of reality than matter. This, as we have seen, does not necessarily mean that it is immaterial, in the sense of being intrinsically independent of matter. In a word, simplicity does not involve spirituality (absolute immateriality). Not only plant and animal souls, but even mineral entelechies, are simple, in the negative sense of excluding extension, corporeality and dispersal into quantitative parts, but they are, none the less, intrinsically dependent on matter and are therefore material principles.

That the soul or vital entelechy is really distinct from its material substrate is apparent from the perennial process of metabolism enacted in the living organism. In this process, matter is the variant and entelechy or specific type is the constant. Hence the two principles are not only distinct, but separable. Moreover, the soul's rôle as a binding-principle

that obstructs dissolution is incompatible with its dispersal into quantitative parts; for such a principle, far from being able to bind, would require binding itself, and could not, therefore, be the primary source of unification in the organism. Finally, the soul must be incorporeal; since, if it were a corporeal mass, it could not be "a formative power pervading the growing mass as a whole" (Wilson); for this would involve the penetration of one body by another. Consequently, the soul is a simple, inextended, incorporeal reality undispersed into quantitative parts.

Introspective psychology bears witness to the same truth; for consciousness reinforced by memory attests *the substantial permanence of our personal identity.* We both think and regulate our practical conduct in accordance with this sense of unchanging personal identity. All recognition of the past means simply this, that we perceive the substantial identity of our present, with our past, selves throughout all the experiences and vicissitudes of life. There is an inmost core of our being which is unchanging and which remains always identical with itself, in spite of the flow of thought and the metabolic changes of the life-cycle. It is this that gives us the sense of being always identically the same person, from infancy to maturity, and from maturity to old age. It is this that constitutes the thread of continuity which links our yesterdays with to-day, and makes us morally responsible for all the deliberate deeds of a lifetime. Courts of law do not acquit a criminal because he is in a different frame of mind from that which induced him to commit murder, nor do they excuse him on the score that metabolism has made him a different mass of flesh from that which perpetrated the crime. Such philosophies as phenomenalism and materialism are purely academic. Even their advocates dare not reduce them to consistent practice in everyday life.

Nor can the cases of *alternating personalities* be adduced as counterevidence. In the first place, these cases are psychopathic and not normal. In the second, they are due, not to a

modification of *personality itself,* but to a modification in the *perception of personality.* Since this perception is, as we shall see, extrinsically dependent on cerebral imagery, any neuropathic affection is liable to modify the perception of personality by seriously disturbing the imagery, on which it depends. But (*pace* Wundt and James) the perception of personality is one thing, and personality itself quite another. Perception does not produce its objects, but presupposes them, and self-perception is no exception to this rule. Introspection, therefore, does not create our personality, but reveals and represents it. If then to the intuition of consciousness our personality appears as an unchanging principle that remains always substantially identical with itself, it follows that this perception must be terminated by something more durable than a flux of transient molecules or a stream of fleeting thought. Unless this perceptive act has for its object some unitary and uniformly persistent reality distinct from our composite, corruptible bodies, and not identified with our transitory thoughts, this sense of permanent personal identity would be utterly impossible. Materialism, which recognizes nothing more in man than a decaying organism, a mere vortex of fluent molecules, is at a loss to account for our consciousness of being always the same person. Phenomenalism, which identifies mind or self with the "thought-stream," is equally impotent to account for this sense of our abiding sameness.

James' attempt at a phenomenalistic explanation of the persistent continuity of self, on the assumption that each passing thought knows its receding predecessor and becomes known, in turn, by its successor, is puerile. To pass over other flaws, this absurd theory encounters an insuperable difficulty in *sleep,* which interrupts, for a considerable interval, the flow of conscious thought. Thought is a transient reality, which passes, so far as its actuality is concerned, and can only remain in the form of a permanent effect. Unless, therefore, there were some *persistent medium* in which the last waking thought could leave a permanent

vestige of itself, the process of relaying the past could never be resumed, and we would lose our personal identity every twenty-four hours. The mind, or subject of thought, then, must be an abiding and unitary principle distinct from our composite bodies, and from our manifold and fleeting thoughts.

Finally, to the two foregoing attributes of the human soul (substantiality and simplicity), we must add a third and crowning attribute, namely, *spirituality*. It is this, and this alone, that differentiates the human from the bestial soul, which latter is but an incomplete complement of matter, incapable of existence apart from matter, and doomed to perish with the dissolution of the organism, as the cylindrical form of a candle perishes with the consumption of the wax by the flame.

All the psychic activities of the brute, such as sensation, object-perception, imagination, associative memory, sensual emotion, etc., are organic functions of the sensitivo-nervous type. In all of them the agent and recipient is not the soul alone, but the psycho-organic composite of soul and organism, that is, the soul-informed sensory and central neurons of the cerebrospinal system. The sensory neurons are nerve cells that transmit centerward the excitations of physical stimuli received by the external sense organs or receptors, in which their axon-fibers terminate. These receptors and sensory neurons are extended material organs proportioned and specialized for receiving physical impressions from external bodies, either directly through surface-contact with the bodies themselves or their derivative particles (*e.g.* in touch, taste and smell), or indirectly through surface-contact with an extended vibrant medium such as air, water, or ether (*e.g.* in hearing and sight). The central neurons of the cerebral cortex are, as it were, the tablets, upon which the excitations transmitted thither by the sensory neurons, record the extended neurograms that constitute the physical basis of the concrete imagery of memory and imagination. Interior senses,

then, like memory and imagination, merely continue and combine what was preëxistent in the exterior senses. Their composite imagery is rigidly proportioned to the extended neurograms imprinted on the cerebral neurons, and these neurograms, in turn, are determined both qualitatively and quantitatively by the physical impressions received by the receptors, and these impressions, finally, are exactly proportioned to the action of the material stimuli in contact with the receptors. Thus the composite images of imagination as well as those of direct perception are proportioned to the underlying neurograms of the cortex and correspond exactly, as regards quality, intensity, and extensity, to the original stimulus affecting the external receptors. Hence men born blind can never imagine color, nor can men born deaf ever imagine sound. An inextended principle, such as the discarnate soul, cannot receive or record impressions from extended vibrant media, or from extended corporeal masses. For this the soul requires the intrinsic coöperation of material receptors. Now, the highest cognitive and appetitive functions of the brute (*e.g.* sense-perception and emotion) are, as has been stated, of the sensitivo-nervous or psycho-organic type, that is, they are functions in which the material organism intimately coöperates; brute animals give no indication of having so much as a single function, which proceeds from the soul alone and which is not communicated to the organism. Hence the bestial soul is "totally immersed" in matter; as regards both operation and existence, it is "intrinsically dependent" upon its material complement, the organism. It never operates save in conjunction with the latter, and its *sole reason for existence* is adequately summed up in saying that it exists, not for its own sake, but merely *to vivify and sensitize the organism.* Consequently, the brute soul, though inextended and incorporeal, belongs, not to the spiritual, but to the material, order of things.

Is the human soul equally material in nature, or does it belong to the spiritual category of being? The state of the question has long since been formulated for us by Aristotle:

"A further difficulty," he says, "arises as to whether all attributes of the soul are also shared by that which has the soul or whether any of them are peculiar to the soul itself: a problem which it is imperative, and yet by no means easy, to solve. It would appear that in most cases it neither acts nor is acted upon apart from the body: as, *e.g.*, in anger, courage, desire, and sensation in general. Thought, if anything, would seem to be peculiar to the soul. Yet if thought is a sort of imagination, or something not independent of imagination, it will follow that not even thought is independent of the body. If, then, there be any functions or affections of the soul that are peculiar to it, it will be possible for the soul to be separated from the body: if, on the other hand, there is nothing peculiar to it, the soul will not be capable of separate existence." ("Peri Psyches," Bk. I, chap. I, 9.) We shall see that the human soul has certain operations which it discharges independently of the intrinsic coägency of the organism, *e.g.*, abstract thought (not to be confounded with the concrete imagery of the imagination) and deliberate volition (to be distinguished from the urge of the sensual appetite). Hence, over and above the organic functions, which it discharges in conjunction with the material organism, the human soul has superorganic functions, of which it is itself, in its own right, the exclusive agent and recipient. In other words, it exists *for its own sake* and not merely to perfect the body.

The Aristotelian argument for the spirituality of the human soul consists in the application of a self-evident principle or axiom to certain facts of internal experience. The axiom in question is the following: "The nature of an agent is revealed by its action"; or, to phrase it somewhat differently: "Every being operates after the same manner that it exists." The factual data, to which reference is made, are man's higher psychic functions, in which the soul alone is the active cause and receptive subject, namely: the rational or superorganic functions of thinking and willing. The argument may be for-

mulated thus: Every agent exists after the same manner that it operates. But in rational cognition and volition the soul acts without the co-agency of the material organism. Therefore the human soul can exist without the co-existence of the material organism. But this is tantamount to saying that it is a spiritual reality irreducible to matter and incapable of derivation from matter. For we define that as spiritual, which exists, or is, at least, capable of existing, without matter. Consequently, the human soul is a supermaterial and immortal principle, which does not need the body to maintain itself in existence, and can, on that account, survive the death and dissolution of its material complement, the organism. Such a reality, as we have seen, cannot be a product of evolution, but can only come into existence by way of creation.

The axiom, that activity is the expression or manifestation of the entity which underlies it, needs but little elucidation. In the genesis of human knowledge, the dynamic is prior to both the static and the entitive. We deduce the nature of the cause from the changes or effects that it produces. Action, in short, is the primary datum upon which our knowledge of being rests. It is the spectrum of solar light emitted by them, which enables us to determine the nature of the chemical elements present in the distant Sun. It is the reaction of an unknown compound with a test reagent that furnishes the chemist with a clue to its composition and structure. It is the special type of tissue degeneration caused by the specific toxin engendered by an invisible disease germ that enables the pathologists to identify the latter, etc., etc. So much for the axiom. Regarding the psychological facts, a more lengthy exposition is required. To begin with, there is *prima facie* evidence against the contention that the higher psychic functions in man are independent of the organism. Injury and degeneration of the cerebral cortex result (very often, at least) in insanity and idiocy. Reason, therefore, is in some way dependent upon the organism. Babies, too, are incapable of rational thought until such a time as the nervous system is

fully developed. Obviously, then, rational functions cannot be spiritual, inasmuch as they are not independent of the organism.

This time-honored objection of materialists is based on a misapprehension. It falsely assumes that spirituality excludes *every* kind of dependence upon a material organism, and that our assertion of the soul's independence of matter is an unqualified assertion. This, however, is far from being the case. It is only *intrinsic* (subjective), and not *extrinsic* (objective), independence of the organism which is here affirmed. An analogy from the sense of sight will serve to make clear the meaning of this distinction. In the act of seeing a tree, for example, our sight is dependent upon a twofold corporeal element, namely, the *eye* and the *tree.* It is dependent upon the eye as upon a corporeal element intrinsic to the visual sense, the eye being a constituent part of the agent and subject of vision; for it is not the soul alone which sees, but rather the soul-informed retina and neurons of the psycho-organic composite. The eye enters as an essential ingredient into the intimate constitution of the visual sense. It is a *constituent part* of the *specific cause* of vision, and it can therefore be said with perfect propriety that the *eye sees.* Such dependence upon a material element is called intrinsic or subjective dependence, and is utterly incompatible with spirituality on the part of that which is thus dependent. But the dependence of sight upon an external corporeal factor, like a tree or any other visible object, is of quite a different nature. Here the corporeal element is outside of the seeing subject and does not enter as an ingredient into the composition of the principal and specific agent of vision. True the tree, which is seen, is coïnstrumental as a provoking stimulus and an objective exemplar, but its concurrence is of an extrinsic nature, not to be confounded with the intrinsic co-agency of the eye in the act of vision. Hence, in no sense whatever can the tree be said to see; for the tree is merely an object, not the principal and specific cause, of vision.

When the dependence of an agent upon a corporeal element is of this sort, it is termed extrinsic or objective dependence. Such dependence upon a material element is *perfectly compatible with spirituality*, which does, indeed, exclude all materiality from the specific agent and subject of a psychic act, but does not necessarily exclude materiality from the object contemplated in such an act. Hence the fact that the thinking soul must abstract its rational concepts from the concrete imagery of a cerebral sense, like the imagination, in no wise detracts from its spirituality, because the dependence of abstract thought upon such imagery is objective or extrinsic, and not subjective or intrinsic.

Psychologists of the sensationalist school have striven to obscure the fundamental distinction which exists between rational thought and the concomitant cerebral imagery. It is, however, far too manifest to escape attention, as the healthy reaction of the modern school of Würzburg indicates. "It cost me great resolution," says Dr. F. E. Schultze, a member of this school, "to say, that, on the basis of immediate experiment, appearances and sensible apprehensions are not the only things that can be experienced. But finally I had to resign myself to my fate." ("Beitrag zur Psychologie des Zeitbewusstseins," p. 277.)

But thought is not only distinct from imagery, often there is marked contrast between the two, both as regards subjective, and objective, characters. Thus our thought may be perfectly clear, precise, and pertinent, while the accompanying imagery is obscure, fragmentary, and irrelevant. "What enters into consciousness so fragmentarily, so sporadically, so very accidentally as our mental images," exclaims Karl Bühler (also of Würzburg), "can not be looked upon as the well-knitted, continuous content of our thinking." (*Archiv. für die ges. Psychol.*, 9, 1907, p. 317.) The same contrast exists with respect to their objective characters. Imagination represents by means of one and the same image what reason represents by means of two distinct concepts, *e.g.* an oasis

and a mirage; and, *vice versa,* reason represents under the single general concept of a rose objects that imagination is forced to represent by means of two distinct images, *e.g.,* a yellow, and a white rose. Imagery depicts only the superficial or exterior properties of an object, whereas thought penetrates beneath the phenomenal surface to interior properties and supersensible relationships. The sensory percept apprehends the existence of a fact, while the rational concept analyzes its nature. Hence sense-perception is concerned with the *reality of existence,* while thought is concerned with the *reality of essence.*

Certain American psychologists employ the term *imageless thought* to designate abstract concepts. The expression is liable to be misunderstood. It should not be construed as excluding all concomitance and concurrence of sensible imagery, in relation to the process of thought. What is really meant is that sensible appearances do not make up the sum-total of our internal experiences, but that we are also aware of mental acts and states which are not reducible to imagery. In other words, we experience thought; and thought and imagery, though concomitant, are not commensurable. The clarity and coherence of thought does not depend on the clarity or germaneness of the accompanying imagery, nor is it ever adequately translatable into terms of that imagery. Thus the universal triangle of geometry, which is not right, nor oblique, nor isosceles, neither scalene nor equilateral, neither large nor small, neither here nor there, neither now nor then, is not visualizable in terms of concrete imagery, although we are clearly conscious of its significance in geometrical demonstrations. Imagery differs according to the person, one man being a visualist, another an audist, another a tactualist, another a motor-verbalist, etc. But thought is the same in all, and consequently it is thought, and not imagery, which we convey by means of speech. Helen Keller, whose imagery is mainly motor and tactile, can exchange views with an audist or visualist on the subject of geometry, even though the amount

of imagery which she has in common with such persons is negligible. *"Eine Bedeutung,"* says Bühler, *"kann man überhaupt nicht vorstellen, sondern nur wissen,"* and Binet, in the last sentence of his "L'Étude expérimentale de l'intelligence," formulates the following conclusion: "Finally—and this is the main fact, fruitful in consequences for the philosophers—the entire logic of thought escapes our imagery."

Nevertheless, thought does not originate in the total absence of imagery, but requires a minimal substrate of sensible images, upon which it is objectively, if not subjectively, dependent. The nature of this objective dependence is explained by the Scholastic theory concerning the origin of concepts. According to this theory, the genesis of our general and abstract knowledge is as follows: (1) We begin with sense-perception, say of boats differing in shape, size, color, material, location, etc. (2) Imagination and sense-memory retain the composite and concrete imagery synthesized or integrated from the impressions of the separate external senses and representing the boats in all their factual particularity, individuality, and materiality, as existent here and now, or there and then, as constructed of such and such material (*e.g.*, of wood, or steel, or iron, or concrete), as having determinate sizes, shapes, and tonnages, as painted white, or gray, or green, as propelled by oar, or sail, or turbine, etc. (3) Then the *active intellect* exerts its abstractive influence upon this concrete imagery, accentuating the essential features which are common to all, and suppressing the individuating features which are peculiar to this or that boat, so that the essence of a boat may appear to the *cognitive intellect* without its concomitant individuation—the essence of a boat being, in this way, isolated from the peculiarities thereof and its various qualities from their subject (representatively, of course, and not physically). (4) The imagery thus predisposed, being no longer immersed in matter, but dematerialized by the dispositive action of the active intellect, becomes coïnstrumental with the latter in

producing a determination in the cognitive intellect. (5) Upon receiving this determination, the cognitive intellect, which has hitherto been, as it were, a blank tablet with nothing written upon it, reacts to express the essence or nature of a boat by means of a spiritual representation or concept —the abstractive act of the active intellect is *dispositive,* inasmuch as it *presents* what is common to all the boats perceived without their differentiating peculiarities; the abstractive act of the cognitive intellect, however, is *cognitive,* inasmuch as it *considers* the essence of a boat without considering its individuation. Such is the abstractive process by which our general and abstract concepts are formed. From a comparison of two concepts of this sort the process of judgment arises, and from the comparison of two concepts with a third arises the process of mediate inference or reasoning. Volition, too, is consequent upon conception, and hence an act of the will (our rational appetite), such as the desire of sailing in a boat, entails the preëxistence of some conceptual knowledge of the nature of a boat. Volition, therefore, presupposes thought, and thought presupposes imagination, which supplies the sensible imagery that undergoes the aforesaid process of analysis or abstraction. Such imagery, however, is a function of the cerebral cortex, and, for this reason, the normal exercise of the imagination presupposes the cerebral cortex in a normal physiological condition; and anything that disturbs this normal condition of the cortex will directly disturb the imagery of the imagination, and therefore indirectly impede the normal exercise of conceptual thought, which is abstracted from such imagery. Hence it is clear that the activity of both the intellect and the will is objectively dependent upon the organic activity of the imagination, and, in consequence, *indirectly* dependent upon the physiological condition of the cerebral cortex, which is the organ of the imagination. Since, however, this dependence is objective rather than subjective, it does not, as we have seen, conflict with the spirituality of rational thought.

The nature of conceptual thought is such as to exclude the participation of matter as a constituent of its specific agent and receptive subject. The objects of a cerebral sense like the imagination are endowed with extension, color, shape, volume, mass, temperature, and other physical properties, in virtue of which they can set up vibrations in an extended medium or modify an extended organ by immediate physical contact. But, while imagination makes us conscious of objects capable of stimulating extended material organs, the objects, of which we are conscious in abstract thinking, are divested of all the sensible properties, extension, and specific energies, which would enable them to modify a material neuron, or produce a physical impression upon a material receptor of any kind whatever. Between an extended material receptor, like a sense-organ or a cerebral neuron, and the nondimensional, dematerialized object or content of an abstract thought, like science, heroism, or morality, there is no conceivable proportion. How can a material organ be affected by what is supersensible, unextended, imponderable, invisible, intangible, and uncircumscribed by the limitations of space and time? Extended receptors are necessary for picking up the vibrations of a tridimensional medium (like air or ether), and they are, likewise, essential for the reception of impressions produced by surface-contact with an exterior corporeal mass. In short, sensory neurons are needed to receive and transmit inward the quantitative and measurable excitations of the material stimuli of the external world, and central neurons are required as tablets upon which these incoming excitations may imprint *extended neurograms*, that are proportionate in intensity and extensity to the external stimulus apprehended, and that underlie and determine the concrete imagery (of which they are the physical basis). But when it comes to perceiving and representing the *meaning* of duty, truth, error, cause, effect, psychology, means, end, entity, logarithms, etc., our mind can derive no benefit from the coöperation of a material organ. In such thinking we

are conscious of that which could not make an impression nor leave a record upon material receptors like neurons. To employ a material organ for the purpose of perceiving abstract essences and qualities would be as futile and pointless as an attempt to stop a nondimensional, unextended, intangible baseball with a catcher's glove. Hence the services of material centers and receptors may be dispensed with, so far as rational thought is concerned. Rational thought cannot utilize the intrinsic coägency of the organism, and it is therefore a superorganic or spiritual function.

That conceptual thought is in no wise communicated to the organism, but subjected in the spiritual soul alone, is likewise apparent from the data furnished by introspection. The conceiving mind apprehends even material objects according to an abstract or spiritualized mode of representation. In other words, in conceiving material objects we expurgate them of their materiality and material conditions, endowing them with a dematerialized mode of mental existence which they could never have, if subjected in their own physical matter, or in the organized matter of the cerebral cortex. Thus, in forming our concept of a material object like a boat, we spiritualize the boat by separating (representatively, of course, and not physically) its nature or essence from the determinate matter (*e.g.*, wood, or steel) of which it is made, and by divesting it of the material and concrete conditions which define not only its physical existence outside of us, but also its imaginal existence within us as a concrete image in our imagination. In other words, we isolate the type or form of a given object from its material substrate and liberate it from the limiting material and concrete individuation, which confine it to a single material subject and localize it definitely in space and time. Now, it is axiomatic that whatever is received is received according to the nature of the receiver. Water, for example, assumes the form of the receptacle into which it is poured, and a picture painted upon canvas is necessarily extended according to the extension of

the canvas. If, therefore, our intellect endows even the material objects, which it perceives, with a dematerialized or spiritualized mode of representation, it follows that the intellect itself is a spiritual power and not an organic sense immersed in concretifying and individualizing matter. Certainly, this ideal or spiritualized mode of existence does not emanate from the material object without nor yet from its vicarious material image in our organic imagination (which, in point of fact, is absolutely impotent to imagine anything except concrete, singular things in all their determinate individuation and quantification). Thought, then, with its *abstract mode of presentation,* cannot, like imagery, be subjected in the animated or soul-informed cortex, but must have the spiritual mind alone as its receptive subject. Our abstract or dematerialized mode of conceiving material objects is a subjective character of thought, proceeding from, and manifesting, the spirituality of the human mind, which represents even material objects in a manner that accords with its own spiritual nature.

But it is not only in the process of abstraction, but also in that of *reflection,* that rational thought manifests its superorganic or spiritual character. The human mind knows that it knows and understands that it understands, thinks of its own thoughts and of itself as the agent and subject of its thinking. It is conscious of its own conscious acts, that is to say, it reflects upon itself and its own acts, becoming an object to itself. The thinking ego becomes an object of observation on the part of the thinking ego, which acquires self-knowledge by this process of reflective thought. In introspection, that which observes is identical with that which is observed. Now such a capacity of self-observation cannot reside in matter, cannot be spatially commensurate with a material organ nor inseparably attached thereto. It is possible only to an immaterial or spiritual principle, devoid of mass and extension, and not subject to the law of the im-

penetrability of matter. In virtue of the law of impenetrability, no two material particles, no two bodies, no two integral parts of the same body, can occupy one and the same place. One part of a body can, indeed, act on another part extrinsic to itself; but one and the same part or particle cannot act upon itself. To become at once observed and observer, a material organ would have to split itself in two, so that the part watched could be distinct from, and spatially external to, the part watching. The power of perfect reflection, therefore, must reside in the spiritual soul, and cannot be bound to, and coëxtensive with, a material organ. Only in this supposition can there be a return of the subject upon and into itself, only in this supposition can there be that identification of observed and observer implied by the process of reflection. H. Gründer, in his "Psychology without a Soul," gives a graphic *reductio ad absurdum* of the contrary assumption: "A fairy tale," he says, "tells of a knight who was beheaded by his victorious foe. But, strange to relate, the vanquished knight rose to his feet, seized his severed head and bore it off, as in triumph. The most remarkable part, however, of the story is that with a last effort of gallantry he took his own head, and—kissed its brow. The climax of this fairy tale is no more absurd than the assumption that a material organ can know itself and philosophize on itself. Only if we admit with the scholastics a simple soul intrinsically independent of any bodily organism, can we explain the possibility of perfect psychological reflexion." (*Cf.* pp. 193, 194.)

For the rest the impossibility of introspection on the part of a material organ is so evident that the materialists themselves freely concede it, and being unwilling to admit the spirituality of the human intellect, they are forced to resort to the disingenuous expedient of denying the *fact* of reflection on the part of the human mind. "It is obvious," says Auguste Comte, "that by an invincible necessity the human mind can observe directly all phenomena except its own. We

understand that a man can observe himself as a moral agent, because in that case he can watch himself under the action of the passions which animate him, precisely because the organs that are the seat of those passions are distinct from those that are destined for the functions of observation. . . . But it is manifestly impossible to observe intellectual phenomena whilst they are being produced. The individual thinking cannot divide himself in two, so that one half may think and the other watch the process. Since the organ observing and the one to be observed are identical, there can be no self-observation." ("Cours de philosophie positive," 1ière leçon.) But an argument is of no avail against a fact, and, as a matter of fact, we do reflect. It is by introspection or reflective thought that we discriminate between our present and our past thoughts, and become conscious of our own consciousness. Our intellect even reflects upon its own act of reflection, and so on indefinitely, so that, unless we are prepared to accept the absurd alternative of an infinite series of thinkers, we have no choice but to identify the subject knowing with the subject known. That our intellect is conscious of its own operations and attentive to its own thoughts, is an evident fact of internal experience, and it is preposterous to tilt against facts by means of syllogisms. When Zeno concocted his aprioristic "proof" of the impossibility of translatory movement, his sophism was refuted by the simple process of walking—*solvitur ambulando*. In like manner, the Comtean sophism concerning the impossibility of reflection is refuted by the simple act of mental reflection—*solvitur reflectendo*. For the rest, we readily concede Comte's contention that an organ is incapable of reflection or self-observation, but we deny his tacit assumption that our cognitive powers are *all* of the organic type. Our intellect, which attends to its own phenomena, thinks of its own thought and reasons upon its own reasoning, cannot be bound to, or coextensive with, a material organ, but must be free from any corporeal organ and rooted in a spiritual principle. In a

word, reflective thought is a superorganic function expressing the spiritual nature of the human mind.

Another proof of the superorganic nature of the human intellect as compared with sentiency, both exterior and interior, is one adduced by Aristotle himself: "But that the impassivity of the sense," he says, "is different from that of intellect is clear if we look at the sense organs and at sense. The sense loses its power to perceive, if the sensible object has been too intense; thus it cannot hear sound after very loud noises, and after too powerful colors or odors it can neither see nor smell. But the intellect, when it has been thinking on an object of intense thought, is not less, but even more, able to think of inferior objects. For sense-perception is not independent of the body, whereas the intellect is." ("Peri Psyches," Bk. III, Ch. iv, 5.)

This temporary incapacitation of the senses consequent upon powerful stimulation is a common experience embalmed in such popular expressions as "a deafening noise," "a blinding flash," "a dazzling light," "a numbing pain," etc. Weber's law of the differential threshold tells us that the intensity of sensation does not increase in the same proportion as that of the stimulus. On the contrary, the more intense the previous stimulus has been, the greater must be the increment added to the subsequent stimulus before it can produce a perceptible increase in the intensity of sensation. In short, stimulation of the senses temporarily decreases their sensitivity with reference to supervening stimuli. The reason for this momentary loss of the power to react normally is evidently due to the organic nature of the senses. Their activity entails a definite and rigidly proportionate process of destructive metabolism in their bodily substrate, the organism. In other words, the exercise of sense-perception involves a commensurate process of decomposition in the neural tissue, which must afterwards be compensated by a corresponding assimilation of nutrient material, before the sense can again react with its pristine vigor. This process of recuperation requires time and temporarily

inhibits the reactive power of the sense in question, the duration of this repair work being determined by the amount of neural decomposition caused by the reaction of the sense to the previous stimulus. When, therefore, a weaker stimulus supervenes in immediate succession to a stronger one, the sense is incapable of perceiving it. All organic activity, in short, such as sense-perception and imagination, is rigidly regulated by the metabolic law of waste and repair.

With the intellect, however, the case is quite different. The intellect is neither debilitated nor stupefied by the discovery of truths that are exceptionally profound, or unusually abstruse, or strikingly evident; nor is it temporarily incapacitated thereby from understanding simpler, easier, or less evident truths. On the contrary, the more comprehensive, the more penetrating, the more perspicuous, the more sublime our intellectual vision is, so much the more is our intellect invigorated and enthused in its pursuit of truth, and its knowledge of the highest truths renders it not less, but more, apt for the understanding of simple and ordinary truths. Obviously, then, the intellect is not bound to a corruptible organ like the senses, but has for its subject a spiritual principle that is intrinsically independent of the organism.

In opposition to this contention, it may be urged that a prolonged exercise of intellectual activity results in the condition commonly known as brain-fag. But this fatigue of the brain is not, as a matter of fact, the *direct* effect of intellectual activity; rather it is the direct effect of the activity of the imagination, and only *indirectly* the effect of intellectual thought. The intellect, as we have seen, requires a constant flow of associated and aptly coördinated imagery as the substrate of its contemplation. Now, the imagination, which supplies this imagery, is a cerebral sense, whose activity is directly proportionate to, and commensurate with, the metabolic processes at work in the cortical cells. Its exercise is directly dependent upon the energy released by the decomposition of the cerebral substance. Prolonged activity of the

imagination, therefore, involves the destruction of a considerable amount of the cortical substance, and results in temporary incapacitation or paralysis of the imagination, which must then be compensated by a process of repair in the cortical neurons, before the imagination can resume its normal mode of functioning. Brain-fag, then, is due to the activity of the imagination rather than that of the intellect. That such is the case appears from the fact that after the initial exertion, which results from the imagination being forced to assemble an appropriate and systematized display of illustrative imagery as subject-matter for the contemplation of the intellect, the latter is henceforth enabled to proceed with ease along the path of a given science, its further progress being smooth and unhampered. Once the preliminary work imposed upon the imagination is finished, the sense of effort ceases and intellectual investigation and study may subsequently reach the highest degrees of concentration and intensity, without involving corresponding degrees of fatigue or depression on the part of the cerebral imagination, just as, conversely speaking, the activity of the cerebral imagination may reach degrees of intensity extreme enough to induce brain-fag in psychic operations wherein the concomitant intellectual activity is reduced to a minimum, *e.g.*, in the task of memorizing a poem, or recitation. Here, in the all but complete absence of intellectual activity, the same fatigue results as that induced by a prolonged period of analytic study or investigation, in which imaginative activity and rational thinking are concomitant. The point to be noted, in this latter case, is that the intellect does not show the same dependence upon the physiological vicissitudes as the imagination. The imagery of our imagination, being rigidly correlated with the metabolic processes of waste and repair at work in the cerebral cortex, manifests correspondingly variable degrees of intensity and integrity, but the intensity of thought is not dependent upon this alternation of excitation and inhibition in the cortex. Hence, while the concomitant imagery is fitful, sporadic, and fragmentary,

intellectual thought itself is steady, lucid, and continuous. The intensity of thought does not vary with the fluctuations of neural metabolism, and may reach a maximum without involving corresponding fatigue in the brain. The brain-fag, therefore, which results from study does not correspond to the height of our intellectual vision, but is due to the intensity of the concomitant imaginative process.

The intellect, therefore, is not subject to the metabolic laws which rigidly regulate organic functions like sense-perception and imagination. Man's capacity for logical thought is frequently unaffected by the decline of the organism which sets in after maturity. All organic functions, however, such as sight, hearing, sense-memory, are impaired in exact proportion to the deterioration of the organism, which is the inevitable sequel of old age. The intellectual powers, on the contrary, remain unimpaired, so long as the cortex is sound enough to furnish the required minimum of imagery, upon which intellectual activity is objectively dependent. There are, in fact, many cases on record where men have remained perfectly sane and rational, despite the fact that notable portions of the cerebral cortex had been destroyed by accident or disease (*e.g.*, tumors). Intellectual thought, therefore, is a super-organic function, having its source in a spiritual principle and not in a corruptible organ.

Such is the spiritualism of Aristotle. That this conception differs profoundly from the ultra-spiritualism of Descartes, it is scarcely necessary to remark. The position assumed by the latter was always untenable, but it is now, more than ever, indefensible in the face of that overwhelming avalanche of facts whereby modern physiological psychology demonstrates the close interdependence and correlation existent between psychic and organic states. Such facts are exploited by materialists as arguments against spiritualism, though it is evident that they have force only against Cartesian spiritualism, and are bereft of all relevance with respect to Aristotelian spiritualism, which they leave utterly intact and unscathed.

In the latter system, sense-perception, imagination, and emotion are acknowledged to be directly dependent on the organism. Again, spiritual functions like thinking and willing are regarded as objectively or extrinsically dependent upon the imagination, which, in turn, is directly dependent on a material organ, namely: the brain. Hence even the rational operations of the mind are indirectly dependent upon the cerebral cortex. The spiritualism of Aristotle, therefore, by reason of its doctrine concerning the direct dependence of the lower, and the indirect dependence of the higher, psychic functions upon the material organism, is able to absorb into its own system all the supposedly hostile facts amassed by Materialism, thereby rendering them futile and inconsequential as arguments against the spirituality of the human soul. In confronting this philosophy, the materialistic scientist finds himself disarmed and impotent, and it is not to be wondered at, that, after indulging in certain abusive epithets and a few cant phrases, such as "metaphysics" or "medieval" (invaluable words!), he prudently retires from the lists without venturing to so much as break a lance in defense of his favorite dogma, that nothing is spiritual, because all is matter. In this predicament, the Cartesian caricature proves a boon to the materialist, as furnishing him with the adversary he prefers, a man of straw, and enabling him to demonstrate his paltry tin-sword prowess. Of a truth, Descartes performed an inestimable service for these modern "assassins of the soul," when he relieved them of the necessity of crossing swords with the hylomorphic dualism of Aristotle by the substitution of a far less formidable antagonist, namely, the psychophysical dualism of mind and matter.

The proofs advanced, in the previous pages, for the spirituality of the human soul are based upon the superorganic function of rational thought. A parallel series of arguments can be drawn from the superorganic function of rational volition. The cognitive intellect has for its necessary sequel the appetitive will, which may be defined as spiritual tendency

inclining us toward that which the intellect apprehends as good. The objects of such volition are frequently abstract and immaterial ideals transcendent to the sphere of concrete and material goods, *e.g.*, virtue, glory, religion, etc. The will of man, moreover, is free, in the sense that it can choose among various motives, and is not compelled to follow the line of least resistance, as is the electric current when passing through a shunt of steel and copper wire. Like the self-knowing intellect, the self-determining will is capable of reflective action, that is, it can will to will. Having its own actions within its own control, it is itself the principal cause of its own decisions, and thus becomes responsible for its conduct, wherever its choice has been conscious and deliberate. External actions, which escape the control of the will, and even internal actions of the will itself, which are indeliberate, are not free and do not entail responsibility. Our courts of law and our whole legal system rests on the recognition of man's full responsibility for his deliberate voluntary acts. The distinction between premeditated murder, which is punished, and unpremeditated homicide, which is not, is purely moral, and not physical, depending for its validity upon the fact of human freedom. It is this exemption from physical determinism, that makes man a moral agent, subject to duties, amenable to moral suasion, and capable of merit or demerit. Finally, the will of man is insatiable, invincible, and inexhaustible. The aspirations of the will are boundless, whereas our animal appetites are easily cloyed by gratification. There is no freezing point for human courage. The animal or sensual appetites wear out and decline with old age, but virtue and will-power do not necessarily diminish with the gradual deterioration of the material organism. Willing, therefore, is a superorganic or spiritual function. Activity which is bound to a material organ cannot tend towards supersensible ideals, cannot escape physical determinism, cannot achieve the reflective feat of spurring itself to action, cannot avoid exhaustion, cannot elude rigid regulation by the laws of organic metab-

olism. For this reason, the brute, whose psychic functions are of the organic type exclusively, is destitute of freedom, morality, and responsibility. Deliberate volition, therefore, like conceptual thought, has its source and subject in man's spiritual soul, and is not a function of the material organism.[1]

[1] To develop the argument drawn from rational volition for the spirituality of the human soul would carry us too far afield. Those who wish to pursue the subject further may consult Chapter VIII of Gründer's monograph entitled "Psychology without a Soul," also his monograph on "Free Will."

G. H. Parker of Harvard, though admitting the fact of human freedom, tries to explain it away in terms of materialism. The following is the description which he gives of his theory: "It is a materialist view which, however, recognizes in certain types of organized matter a degree of free action consistent with human behavior and the resultant responsibility." (*Science*, June 13, 1924, p. 520.) Freedom, in other words, "emerges" from matter having a peculiar "type of organization."

This view must be interpreted in the light of the philosophy of "Emergent Evolution," which Parker holds in common with C. Lloyd Morgan and R. W. Sellars. The philosophy in question recognizes in nature an ascending scale of more and more complexly organized units, starting with protons and electrons, at the bottom, and culminating in the human organism, at the top. At each higher level of this cosmic scale we find higher units formed by coalescence of the simpler units of a lower level. These higher units, however, are *something more* than a mere summation of the lower units; for, in addition to *additive* properties that can be predicted from a knowledge of the components, they exhibit genuinely *new* properties which, not being mere sums of the properties of the component units, are unpredictable on that basis. Given, for example, the weight of two volumes of hydrogen and one volume of oxygen, we could predict an *additive* property such as the *weight* of the compound, *i.e.* the water, formed by their combination. Other properties, of the compound, however, such as liquidity, are not foreshadowed by the properties of the component gases. Similarly, the weight of carbon disulphid (CS_2) is an additive function of the combining weights of sulphur and carbon, but the other properties of this mobile liquid are not predictable on the basis of the properties of sulphur and carbon. Hence *two* kinds of properties are distinguished: (1) *additive* (quantitative) properties called *resultants*, which are predictable; (2) *specificative* (qualitative) properties called *emergents*, which are unprecedented and unpredictable. Freedom and intelligence, accordingly, are pronounced to be *emergents* of matter organized to that degree of complexity which we find in man.

This dualism of resultance and emergence is merely a new verbal vesture for the hylomorphic dualism of Aristotle. The *additive* proper-

Two additional facts may be cited as bringing into strong relief the basic contrast existing between the higher or rational, and the lower or animal psychosis in man. The first is the occurrence of irreconcilable opposition or conflict. The imagination, for example, antagonizes the intellect by visualizing as an extended speck of chalk or charcoal the mathematical point, which the intellect conceives as destitute of extension and every other property except position. Similarly, the effort of our rational will to be faithful to duty and to uphold

ties (*resultants*) are based on *matter,* which is the principle of *continuity.* The *specificative* (constituitive or qualitative) properties called emergents are rooted in *entelechy* (form), which is the principle of *novelty.* In fact, entelechy (form) itself is *an emergent of matter* just as the specificative properties are *emergents* of matter, with the sole difference that *entelechy* is *the primary emergent* of matter, whereas the specificative or qualitative properties are *secondary emergents.* For in Aristotelian philosophy, entelechy is not, as it is in Neo-vitalism, "an alien principle inserted into matter" abruptly and capriciously "at the level of life," but a *primary emergent* and *constituent* of matter both living and non-living. In fine, entelechy is an *emergent* of matter in all the units of nature from the simplest atom to the most complex plant or animal organism. The only entelechy, which is not an *emergent,* but an *insert* into matter, is the *spiritual human soul.* Neither the human soul nor the *superorganic* functions rooted in it, namely, abstraction, reflection, and election, are *emergents.* Here we have *novelty without continuity,* and therefore not *emergence* (eduction), but *insertion* (infusion).

In his "Emergent Evolution," 1923, Lloyd Morgan lays it down as axiomatic that *emergence involves continuity*—"There may often be resultants," he says, "without emergence; but there are no emergents that do not involve resultant effects also. Resultants give quantitative continuity which underlies new constitutive steps in emergence." (*Op. cit.,* p. 5.) Now our proofs for human spirituality consist precisely in the *complete exclusion of quantitative continuity* between *organic* functions (e.g. sensation) and *superorganic* functions (e.g. conceptual thought and free volition). Hence, by the very axiom which Morgan himself formulates, the human soul and its *superorganic functions* are excluded from the category of material *emergents.* If there can be no emergence without quantitative continuity, then the human soul is not an *emergent from,* but an *insert into,* matter. *Free choice,* too, it is needless to say, is not an *emergent of matter,* but an *expression of the supermaterial nature of the human soul.* So much for the new-old dualism of emergence and resultance.

ideals is antagonized by the sensual impulses of the animal appetite, which seek immediate gratification at the expense of remote considerations that are higher. Such antagonism is incompatible with any identification of the warring factors, that is, of our rational, with our sentient, functions; for, wherever opposition is in evidence, there *a fortiori* a real distinction must be recognized. The understanding and the will, therefore, differ radically from sense and sensual appetite. The second significant fact is the domination exerted by reason and will over the cognitive and appetitive functions of the organic or sentient order. Our intellect criticizes, evaluates and corrects the data of sense-perception, it discriminates between objective percepts and illusions and hallucinations, it distinguishes dreams from realities, it associates and dissociates imagery for purposes of comparison, contrast, illustration, or analysis. Moreover, it not only shows its superiority to sense by supervising, revising, and appraising the data of sentient experience, but it manifests its discontent at the inaccuracy and limitation of sense by the invention and use of instrumentation (*e.g.* ear trumpets, spectacles, microscopes, telescopes, spectroscopes, polariscopes, periscopes, etc.) to remedy the defects or increase the range of sense-perception, etc. This phenomenon is without parallel among brute animals, and is a patent manifestation of the superiority of human psychology. In like manner, the will demonstrates its preëminence over the organic or animal appetite, by exerting supreme control over the passions and impulses of our lower nature. In fact, it is able to bridle and repress the impulses of sensuality even in the immediate presence of sensible stimuli that would irresistibly determine the brute to a gratification of its animal lusts; and it can force the struggling and reluctant flesh to undergo a crucifixion for supersensible motives that make no appeal to the beast. The understanding and the will, therefore, are essentially superior to the organic psychosis that they control, namely, the sentient consciousness and sensual appetite, which we share in common with the brute, but which,

in the latter, give no evidence whatever of rational or moral control.

§ 4. Darwinian Anthropomorphism

The spiritual mind of man represents an eminence to which evolving matter can never attain. This, then, is the hill that must needs be laid low, if the path of Darwinian materialism is to be a smooth one. There is, therefore, nothing very surprising in the fact that Darwin and his followers, from Huxley down to Robinson, have done all in their power to obscure and belittle the psychological differences between man and the brute. The objective of their strategy is twofold, namely, the *brutalization of man* and its converse, the *humanization of the brute*. The ascent will be easier to imagine, if man can be depressed, and the brute raised, to levels that are not far apart. To this end, the Darwinian zealots have, on the one hand, spared no pains to minimize the superiority and dignity of human reason by the dissemination of sensistic associationism, psychophysical parallelism, and various other forms of "psychology without a soul"; and they have striven, on the other hand, to exalt to the utmost the psychic powers of the brute by means of a crude and credulous anthropomorphism, which, for all its scientific pretensions, is quite indistinguishable from the naïveté of the author of "Black Beauty" [2] and the sentimentality of S. P. C. A. fanatics, vegetarians, anti-vivisectionists, etc. The first of these tendencies we have already discussed, the second remains to be considered.

When it comes to anthropomorphizing the brute, Darwin has not been outdistanced by the most reckless of his disciples. Three entire chapters of the "Descent of Man" are filled with this "vulgar psychology" (as Wundt so aptly styles it). It is the sum and substance of the entire fabric of argumentation, which he erects in support of his thesis that "the difference in

[2] Title of a horse's autobiography by Anna Sewall, the horse's *alter ego*.

mind between man and the higher animals is certainly one of degree and not of kind." (*Cf. op. cit.*, chs. III-V.) Haeckel, Huxley, and Clifford attained to equal proficiency in the sport. Subsequent philosophers parroted their bold metaphors and smart aphorisms, and the game went on merrily till the close of the century. Then a badly needed reaction set in under the auspices of Wundt, Lloyd Morgan, and Thorndike, who insisted on abandoning this naïve impressionism in favor of more critical methods.

In his "Vorlesungen über die Menschen und Tierseele" (cf. 2nd ed., p. 370), Wundt proclaims his rupture with the impressionistic school in the following terms: "The one great defect of this popular psychology is that it does not take mental processes for what they show themselves to be to a direct and unprejudiced view, but imports into them the reflections of the observer about them. The necessary consequence for animal psychology is that the mental actions of animals, from the lowest to the highest, are interpreted as acts of the understanding. If any vital manifestation of the organism is capable of possible derivation from a series of reflections and inferences, that is taken as sufficient proof that these reflections and inferences actually led up to it. And, indeed, in the absence of a careful analysis of our subjective perceptions we can hardly avoid this conclusion. Logical reflection is the logical process most familiar to us, because we discover its presence when we think about any object whatsoever. So that for popular psychology mental life in general is dissolved in the medium of logical reflection. The question whether there are not perhaps other mental processes of a simpler nature is not asked at all, for the one reason that whenever self-observation is required, it discovers this reflective process in the human consciousness. The same idea is applied to feelings, impulses, and voluntary actions which are regarded, if not as acts of intelligence, still as effective states which belong to the intellectual sphere.

"This mistake, then, springs from ignorance of exact psycho-

logical methods. It is unfortunately rendered worse by the inclination of animal psychologists to see the intellectual achievements of animals in the most brilliant light. . . . Unbridled by scientific criticism the imagination of the observer ascribes phænomena in perfectly good faith to motives which are entirely of its own invention. The facts reported may be wholly true; the interpretation of the psychologist, innocently woven in with his account of them, puts them from first to last in a totally wrong light. You will find a proof of this on nearly every page of the works on animal psychology." (English Translation by Creighton & Titchener, p. 341.)

Wundt's warning against taking at their face value popular, or even so-called scientific, accounts of wonderful feats performed by animals is very salutary. The danger of subjective humanization of bestial conduct is always imminent. We are unavoidably obliged to employ the analogy of our own animal nature and sentient consciousness as our principal clue to an understanding of brute psychology, but we must beware of pressing this analogy based on our own consciousness to the uncritical extreme of interpreting in terms of our highest psychic operations animal behavior that, in itself, admits of a far simpler explanation. According to the principle of the minimum, it is unscientific to assume in a given agent the presence of anything that is not rigidly required for the explanation of its observed phenomena. We must refrain, therefore, from reading into the consciousness of an animal what is not really there. We must abstain from transporting our own viewpoint and personality into a brute, by imagining, with Darwin, that we discern a "sense of humor," or a "high degree of self-complacency" in some pet animal, like a dog. In general, we can rest assured that animals are quite innocent of the motivation we ascribe to them. All their manifestations of the psychic order are adequately explicable in terms of sensory experience, associative memory, instinct, and the various automatisms of their innate and conditioned reflexes. There is no ground

whatever for supposing the brute to possess the superorganic power of understanding commonly known as *intelligence.*

Etymologically speaking, the abstract term "intelligence," together with the corresponding concrete term "intellect," is derived from the Latin: *intus-legere,* signifying to "read within," the fitness of the term being based upon the fact that the intellect can penetrate beneath the outer appearances of things to *inner* aspects and relations, which are hidden from the senses. In its proper and most general usage, intelligence denotes a cognoscitive power of abstraction and generalization, which, by means of conceptual comparison, discovers the supersensible relationships existent between the realities conceived, in such wise as to apprehend substances beneath phenomena, causes behind effects, and remote ends beyond proximate means.

Certain animal psychologists, however, refuse to reserve the prerogative of intelligence for man. Bouvier's "La Vie Psychique des Insectes" (1918), for example, contains the following statement: "Choice of a remarkably intellectual nature, is even more noticeable in the instinctive manifestations of individual memory. The animal, endowed with well-developed senses and nervous system, not only reacts to new necessities by new acts, but associates the stored up impressions of new sensations and thereby appropriately directs its further activities. Thus, by an intelligent process, new habits are established, which by heredity become part of the patrimony of instinct, modifying the latter and constituting elements essential to its evolution. Of these instincts acquired through an intelligent apprenticeship Forel was led to say that they are reasoning made automatic, and it is to them particularly that we may apply the idea of certain biologists that instincts are habits which have become hereditary and automatic." (Smithson. Inst. Rpt. for 1918, p. 454.)

It is extremely doubtful, however, whether Bouvier is here using the term intelligence in its proper sense. Indeed, his words convey the impression that what he means by intelli-

gence is an *ability to profit by experience.* Now, ability to profit by experience may, under one set of circumstances, involve the power of logical reflection and inference, while, under another set of circumstances, it may imply nothing more than the power of associative memory. In the latter case, the facts are explicable without any recourse to psychic powers of a superorganic nature, and, in point of fact, it often happens that the very zoöpsychologists, who insist on attributing this sort of "intelligence" to brutes, are most emphatic in denying that brutes are endowed with *reason.* In any case, it is unfortunate that the word intelligence is now used in two entirely different senses. This new and improper sense, being unrelated to the etymology, and out of harmony with the accepted use of the term, serves only to engender a confusion of ideas. It should be suppressed, in order to avoid misunderstandings.

That men should be deluded, however, into crediting animals with "intelligence" (properly so-called) is not at all surprising, when we reflect on the source of this misapprehension; for we find combined in the animal two important factors, whose association closely simulates intelligence, namely, *sentient consciousness* and *unconscious teleology.* Now teleology is not *inherent* or *subjective* intelligence, but rather an *objective expression* and *product* of intelligence. It exists in unconscious mechanisms like phonographs and adding machines, and it is, likewise, manifest in unconscious organisms like plants. Here, however, there is no danger of confounding it with conscious intelligence, because machines and plants do not possess consciousness in any form whatever. But in animals, on the contrary, teleology is intimately associated with sentient consciousness. Here the teleological automatisms of instinct are not wholly blind and mechanical, but are guided by sense-perception and associative memory. It is this combination of teleology with sentient "discernment" (as Fabre styles it) that conveys the illusory impression of a conscious intelligence. Careful analysis, however, of the facts, in conjunction with judicious experiments, will, in every instance,

enable the observer to distinguish between this deceptive semblance of intelligence and that inherent rational power of abstraction, classification, and inference which is the unique prerogative of the human being. A genuine intelligence of this sort need not be invoked to explain any of the phenomena of brute psychology. All of them, from the highest to the lowest, are explicable in terms of the sensitivo-nervous functions. To illustrate the truth of this statement let us cite a few typical examples of animal behavior, that are sometimes regarded as manifestations of intelligent or rational consciousness on the part of the brute.

Animals, it is pointed out, learn by experience. The tiny chick that has been stung by a wasp, for instance, learns to avoid such noxious creatures for the future. This is, indeed, "learning by experience." Obviously, however, it does not consist in an inference of a new truth from an old truth. On the contrary, it amounts to nothing more than a mere association of imagery, formed in accordance with the *law of contiguity in time*, sanctioned by the animal's sensual appetite, and persistently conserved in its sentient memory. A bond of association is formed between the visual image of the wasp and the immediately ensuing sensation of pain. Thereafter the wasp and the pain are associated in a single complex, which the sensile memory of the animal permanently retains. We are dealing with a mere *association of contiguity*, and nothing further is required to explain the future avoidance of wasps by the chick. The abilities acquired by animals through the trial and error method are to be explained in the same way. A horse confined within an enclosure, for example, seeks egress to the fresh grass of the pasture. The fact that repeated exits through the gate of the enclosure have associated the image of its own access to the pasture with the particular spot where the gate is located induces it to approach the gate. Its quest, however, is balked by the fact that the gate is closed and latched. Thereupon, it begins to chafe under the urge of frustrated appetite. Certain actions ensue, some spon-

taneous and others merely reflex movements. It paws the ground, prances about, and rubs its nose against the gate. Its futile efforts to pass through the closed gate continue indefinitely and aimlessly, until, by some lucky accident, its nose happens to strike against the latch and lift it sufficiently to release the gate. This causes the gate to swing ajar, and the horse rushes out to food and freedom. By the law of contiguity, the vision of free egress through the gate is thereafter firmly associated in the horse's sense-memory with the final sensation experienced in its nose just prior to the advent of the agreeable eventuation of its prolonged efforts. Henceforth the animal will be able to release itself from the enclosure by repeating the concatenated series of acts that memory associates with the pleasurable result. On the second occasion, however, the more remote of its futile acts will have been forgotten, and the process of opening the gate will occupy less time, though probably a certain amount of useless pawing and rubbing will still persist. Gradually, however, the number of inefficacious actions will diminish, until, after many repetitions of the experience, only those actions which directly issue in the desirable result will remain in the chain of impressions retained by memory, all others being eliminated. For, by a teleological law, making for economy of effort, all impressions not immediately and constantly connected with the gratification of animal appetites tend to be inhibited. Pawlow's experiments on dogs show that impressions which coincide in time with such gratification tend to be recalled by a return of the appetitive impulse, but are soon disconnected from such association and inhibited, if they recur independently of the recurrence of gratification. For this reason, the horse tends to remember more vividly those actions which are more closely connected with the pleasurable result, and, as its superfluous actions are gradually suppressed by a protective process of inhibition, it gradually comes to run through the series of actions necessary to open the gate with considerable accuracy and dispatch.

The point to be noted, however, is that the horse does not

discursively analyze this concatenated series of associated stimulators and actions; for, let the concrete circumstances be changed never so little, the horse will at once lose its laboriously acquired ability to open the gate. Such, for example, will be the result, if the position of the gate be transferred to another part of the enclosure. The horse, therefore, is incapable of adapting its acquired ability to new conditions. It can only rehearse the original series in all its initial concreteness and stereotyped specificity; and it must, whenever the circumstances are changed, begin once more at the beginning, and rearrive by trial and error at its former solution of the problem. The reason is that the horse merely *senses,* but does not *understand,* its own solution of the problem. The sense, however, cannot abstract from the here and now. Consequently, the human infant of two summers is enabled by its dawning intelligence to *adapt old means to new ends,* but the ten-year-old horse cannot adjust its abilities to the slightest change in the concrete conditions surrounding the original acquisition of a useful habit. The cognitive powers of an animal are confined to the sphere of concrete singularity, it has no power to abstract or generalize.

The selfsame observation applies to the tricks which animals "learn" through human training. Their sensitive memory is very receptive and retentive. Hence, by means of a judicious alternation of "rewards" and "penalties" (*e.g.* of sugar and the whip), a man can, as it were, inscribe his own thoughts on the tablets of the brute's memory, in such a way as to force the latter to form habits that appear to rest upon a basis of intelligence. And so, indeed, they do, but the intelligence is that of the trainer and not that of the animal, which is as destitute of intrinsic intelligence as is a talking phonograph, upon whose records a man can inscribe his thoughts far more efficiently than he can write them in terms of the neurographic imagery of the canine, equine, or simian memory.

The trained monkey always renders back without change the original lesson imparted by its human trainer. The lesson

as first received becomes an immutable reaction-basis for the future. With a school child, however, the case is quite different. It does, indeed, receive "an historical basis of reaction," when the teacher illustrates the process of multiplication by means of an example on the blackboard. But it does not receive this information passively and render it back in the original stereotyped form. On the contrary, it analyzes the information received, and is able thereafter to reapply the analyzed information to new problems differing in specificity from the problem that the teacher originally worked out on the blackboard. The human pupil does not, like the monkey or the phonograph, render back what it has received in unaltered specificity. His reaction differs from its original passive basis. To borrow the words of Driesch, he "uses this basis, but he is not bound to it as it is. He dissolves the combined specificities that have created the basis." ("The Problem of Individuality," pp. 27, 28.) The brute, therefore, cannot "learn," or "be taught" in the sense of intellectual comprehension and enlightenment. "We see," says John Burroughs somewhere, "that the caged bird or beast does not reason because no strength of bar or wall can convince it that it cannot escape. It cannot be convinced because it has no faculties that are convinced by evidence. It continues to dash itself against the bars not until it is convinced, but until it is exhausted. Then slowly a new habit is formed, the cage habit. When we train an animal to do stunts, we do not teach it or enlighten it in any proper sense, but we compel it to form new habits."

Human beings, however, can be *taught* and *enlightened* under the most adverse circumstances. Even those unfortunates are susceptible to it, who, like Laura Bridgman, Helen Keller, Martha Obrecht, Marie Heurtin, and others, have been blind and deaf and dumb from infancy or birth. With nearly all the light of sensibility extinguished, there was, nevertheless, latent within them something of which a perfectly normal ape, for all the integrity of its senses, is essentially destitute, namely, the superorganic power of reason. Reason, however,

is extrinsically dependent on organic sensibility, and, consequently, "the gates of their souls" were closed to human converse, until such a time as the patient kindness and ingenuity of their educators devised means of reciprocal communication on a basis of tactile signals. Thereupon they revealed an intelligence perfectly akin to that of their rescuers. Years of similar education, however, would be futile in the case of an ape. The "gates of the soul" would never open, because the ape has no rational soul, to which the most ingenious trainer might gain access, in which respect it differs fundamentally from even the lowest savage. A being that lacks reason may be *trained* by means of instruction, but it can never be *enlightened* by it.

Another consideration, that is occasionally urged in proof of bestial intelligence, is the fact that birds, mammals, and even insects communicate with one another by means of sounds or equivalent signals, which are sometimes remarkably diversified in quality and consequent efficacy. "Since fowls," writes Darwin, "give distinct warnings for danger on the ground, or in the sky, from hawks . . . , may not some unusually wise ape-like animal have imitated the growl of a beast of prey, and thus told his fellow monkeys the nature of the expected danger? This would have been a first step in the formation of a language." ("Descent of Man," 2nd ed., ch. III, pp. 122, 123.) This is saltatory logic with a vengeance! Darwin leaps at one bound across the entire chasm between irrationality and rationality, without pausing to build even the semblance of a bridge. Given an animal with the foresight and inventiveness requisite to employ onomatopœia for the *purpose* of specifying the *nature* of an expected *danger*, in the *interest* of its fellows, and we need not trouble ourselves further about plausibleizing any transition; for so "unusually wise" an ape is already well across the gap that separates reason from unreason, and far on its way towards the performance of all the feats of which reason is capable. After swallowing the camel of so much progress, it would be straining at a gnat to deny such a paragon of simian genius the mere power of articulate speech. Of course,

if imagination rather than logic, is to be the dominant consideration in science, there is no difficulty in imagining animals to be capable of thinking or doing anything we choose to ascribe to them, as witness *Æsop's Fables.* But, if sober and critical judgment be in order, then, evidently, from the simple fact that an animal has diversified cries manifestative of different emotions or degrees of emotion (*e.g.* of fear or rage) and capable of arousing similar emotions in other animals of the same species, it by no means follows that such an irrational animal can *adapt a means to an end* by using mimicry *in order to give notification* of approaching danger, and *to specify the nature of the danger* in question.

This stupid anthropomorphism arises from Darwin's failure to appreciate the fundamental distinction that exists between the "language" of animals, which is indicative, emotional, and inarticulate, and human language, which is descriptive, conceptual, and articulate. Brute animals, under the stress of a determinate passion or emotion, give vent impulsively and unpremeditatedly to instinctive cries indicative of their peculiar emotional state. Moreover, these emotionalized sounds are capable of arousing kindred emotions in the breasts of other animals of the same species, since organisms of the same species are syntonic with (*i.e.* attuned to) one another. Hence these reflex or instinctive cries have, no doubt, a teleological value, inasmuch as they serve to protect the race by inciting a peculiar flight-reaction in those that are not in immediate contact with the fear-inspiring object. This so-called warning, however, is given without reflection or intention on the part of the frightened animal, and is simply sensed, but not interpreted, by the other animals that receive it.

This premised, it is easy to discriminate between bestial and human language. The former is not articulate, that is to say, the sounds of which it is composed have not been elaborated by analysis and synthesis into phonetic elements and grammatical forms. In the second place, it is emotional and not conceptual, because it is manifestative of the emotions or

passions (which are functions of the organic or sensual appetite), and not of rational concepts. In the third place, it is indicative, that is, it merely signalizes a determinate emotional state, as a thermometer indicates the temperature, or a barometer the atmospheric pressure. It is not, therefore, descriptive, in the sense of being selected and arranged in syntactic sequence for the express purpose of making others realize one's own experiences. The rational language of man, on the contrary, is not emotional. Only a negligible portion of the human vocabulary is made up of emotional interjections. It consists, for the most part, of sounds descriptive of thought, to express which an elaborate system of vowels and consonants are discriminated and articulated on the basis of social agreement, the result being a conventional vocal code invented and used for the express purpose of conveying, not emotions or imagery, but general and abstract concepts.

§ 5. The True Significance of Instinct

A third class of facts commonly cited as evidence of bestial intelligence are the remarkable phenomena of *instinct.*[3] The beaver acts as though it were acquainted with the principles of hydraulics and engineering, when it maintains the water at the height requisite to submerge the entrance to its dwelling by building a dam of mud, logs, and sticks across the stream at a point below the site of its habitation. The predatory wasp *Pompilius* is endowed with surgical art, that suggests a knowledge of anatomy, inasmuch as it first disarms and afterwards paralyzes its formidable prey, the *Lycosa* or black Tarantula. Another predatory wasp, the *Stizus ruficornis*, disables Mantids in a similar fashion. One of the American

[3] J. Henri Fabre and Erich Wasmann, S.J., have formulated very sound and critical views on the subject of instinct. The works of these authors are now available in English. (*Cf.* de Mattos' translation of the *Souvenirs etymologiques:* "The Mason Bees," Ch. VII; "The Bramble Bees," Ch. VI; "The Hunting Wasps," Chs. IX, X, XX; *cf.* also Wasmann's *Instinct and Intelligence,* and *Psychology of Ants and of Higher Animals,* Engl. translation by Gummersbach.)

Pompilids, the black wasp *Priocnemis flavicornis*, is an adept in the art of navigation, since it adopts the principle of the French hydroglissia (an air-driven boat which skims the water under the propulsion of an aeroplane propeller). This insect tows a huge black spider several times its own size and too heavy to be carried, propelling its prey with buzzing wings along the open waterway, and leaving behind a miniature wake like that of a steamer. It thus avoids the obstacles of the dense vegetation, and saves time and energy in transporting the huge carcass of its paralyzed quarry to the haven of its distant burrow. Spiders like the *Epeira,* for example, are endowed with the mathematical ability of constructing their webs on the patterns of the logarithmic spiral of Jacques Bernouilli (1654-1705), a curve which it took *man* centuries to discover. The dog infested with parasitic tapeworms (*Taenia*) evinces a seeming knowledge of pharmaceutics, seeing that it will avidly devour Common Wormwood (*Artemisia absynthium*), an herb which it never touches otherwise.

In all these cases, however, as we have previously remarked, the illusion of intelligence is due to the combination of teleology or objective purposiveness with sentient consciousness. But teleology is nothing more than a material expression of intelligence, not to be confounded with subjective intelligence, which is its causal principle. When the cells of the iris of the eye of a larval salamander regenerate the lens in its typical perfection, after the latter has been experimentally destroyed, we behold a process that is objectively, but not subjectively, intelligent. In like manner the instinctive acts of an animal are teleological or objectively purposive, but do not proceed from an intelligence *inherent in the animal,* any more than the intelligent soliloquy delivered by a phonograph proceeds from a conscious intelligence inherent in the disc. In the animal, sentient consciousness is associated with this teleology or objective purposiveness, but such consciousness is only aware of what can be sensed, and is, therefore, *unconscious of purpose,* that

is, of the supersensible link, which connects a means with an end. "Instinct," to cite the words of Wm. James, "is usually defined as the faculty of acting in such a way as to produce certain ends, without foresight of the ends, and without previous education in the performance." ("'Principles of Psychology," vol. II, c. xxiv, p. 383.) Hence the unconscious and objective purposiveness, which the human mind discerns in the instinctive behavior of brutes, is manifestative, not of an intelligence within the animal itself, but only of the infinite intelligence of the First Cause or Creator, Who imposed these laws replete with wisdom upon the animal kingdom, and of the finite intelligence of man, who is capable of recognizing the Divine purpose expressed, not only in the instincts of animals, but in all the telic phenomena of nature. Such marvels are not the fortuitous result of uncoördinated contingencies. Behind these correlated teleologies of the visible universe there is a Supreme Intelligence, which has "ordered all things in measure, and number, and weight." (*Wisdom:* XI, 21.) "And this universal geometry," says Fabre, in allusion to the mathematics of the Epeira's web, "tells of an Universal Geometrician, whose divine compass has measured all things. I prefer that, as an explanation of the logarithmic curve of the Ammonite and the Epeira, to the Worm screwing up the tip of its tail. It may not perhaps be in accordance with latter-day teaching, but it takes a loftier flight." ("Life of the Spider," p. 400.)

But, though the teleology of instinct is wonderful in the extreme, the element of psychic regulation is so subordinate and restricted, that, far from postulating *intelligent* control, certain scientists go so far as to deny even *sentient* control, in the case of instinctive behavior. Animals, in their opinion, are nothing more than "reflex machines," a view which coincides with that of Descartes, who regarded animals as unconscious automatons. "The instincts," says Pawlow, "are also reflexes but more complex." (*Science,* Nov. 9, 1923, p. 359.) The late Jacques Loeb was a protagonist of the view that

instincts are simply *metachronic chain-reflexes,* in which one elementary process releases another, each preceding phase terminating in the production of the succeeding phase, until the entire gamut of concatenated arcs has been traversed. Hence, John B. Watson, the Behaviorist disciple of Loeb, defines instinct as "a combination of congenital responses unfolding serially under appropriate stimulation."

But, if Darwinian anthropomorphism sins by excess, Loeb's mechanism sins by defect, and fails to account for the indubitable variability of instinctive behavior. For, however fixed and stereotyped such behavior may be, it manifests unmistakable adaptation to external circumstances and emergencies, as well as subordination to the general physiological condition of the organism, phenomena that exclude the idea of fatal predetermination according to the fixed pattern of a determinate series of reflex arcs. As Jennings has shown, synaptic coördination in the neural mechanism cannot be more than a partial factor in determining serial responses. The state of the organism as a whole must also be taken into account. (Cf. "Behavior of the Lower Organisms," p. 251.) Thus an earthworm may turn to the right simply because it has just turned to the left, but this so-called "chain-reflex" does not involve an invariable and inevitable sequence of events, since the earthworm may turn twice or thrice to the left, before the second reaction of turning to the right comes into play. Any animal, when sated, will react differently to a food stimulus than it will when it is starved, by reason of its altered organic condition. We have something more, therefore, to reckon with than a mere system of reflexes released by a simple physical stimulus.

The second type of variability manifested by instinct is its capacity for complex and continuous adjustment to variable environmental circumstances. Thus predatory animals, such as wasps, crabs, spiders, and carnivorous mammals, accommodate themselves appropriately and uninterruptedly to the changing and unforeseeable movements of the prey they are

engaged in stalking, giving evidence in this way of the regulation of their hunting instincts by sensory impressions. Whether this element of psychic control is based upon object-perception, or simple sensation, and whether it involves a sensual impulse, or is merely sensori-motor, we have, naturally, no direct means of ascertaining. But the presence of some sort of sensory regulation is evident enough, *e.g.* in the prompt and unerring flight of vultures to distant carrion. Moreover, there is a close analogy between our sense organs and those of an animal. Particularly, in the case of the higher animals, the resemblance of the sense organs and nervous system to our own is extremely close, so much so that even the localization of sensory and motor centers in the brain is practically identical in dogs, apes, and men. Moreover, the animals make analogous use of their sense organs, orientating them and accommodating them for perception, and using them to inspect strange objects, etc., *e.g.* they turn their eyes, prick up their ears, snuff the wind, etc. Again, analogous motor and emotional effects result from the stimulation of their sense organs, and brutes make emotional displays of anger, exultation, fear, etc., similar to our own. Hence it is to be presumed that they have similar sensuous experiences. The analogy, however, must not be pressed further than the external manifestations warrant. With brute animals, the manifestations in question are confined exclusively to phenomena of the sensuous order.

Another indication of sensory control is found in the repair-work performed by animals endowed with the constructive instinct. C. F. Schroeder, for instance, experimenting on certain caterpillars, found that they repaired their weaving, whenever it was disturbed by the experimenter. Fabre, too, discovered that a Mason-bee would plaster up holes or clefts marring the integrity of its cell, provided that the bee was actually engaged in the process of plastering at the time, and provided that the experimenter inflicted the damage at the level, and within the area, of the construction work on which

the bee was then engaged. In a word, if the damage inflicted could be repaired by a simple continuation or extension of its actual work of the moment, the bee was able to cope with the emergency. There are other ways, too, in which the animal adapts its constructive instincts to external circumstance. Fabre tells us that the Bramble-bee *Osmia,* which builds a train of partitioned cells in snail shells or in hollow reeds, will victual first and then plaster in a partition, if the reed be narrow, but will first plaster a partition, and then introduce honey and pollen through a hole left unclosed in the partition, whenever the reed is of greater diameter. This reversal of the procedure according to the exigencies of the external situation does not suggest the chain-reflex of Loeb. (Cf. "The Bramble-Bee," pp. 214-217.) Another kind of adaptation of instinct to external circumstances consists in the economical omission of the initial step of a serial construction, in cases where the environmental conditions provide a ready-made equivalent. "The silkworm," says Driesch, "is said not to form its web of silk if it is cultivated in a box containing tulle, and some species of bees which normally construct tunnels do not do so if they find one ready made in the ground, they then only perform their second instinctive act: separating the tunnel into single cells." ("Science & Phil. of the Organism," vol. II, p. 47.)

Driesch's analysis of the constructive instinct shows that these facts of adaptation or regulation fit in with the idea of sensory control rather than with that of a chain-reflex. In the supposition that the successive stages of instinctive construction are due to a chain-reflex, consisting of a series of elementary motor reactions *a, b, c,* etc., in which *a* produces the external work A and, on terminating, releases *b*, which, in turn, produces external work B and releases *c*, etc., clearly *b* could never appear before *a*, and the sight of A ready-made would not inhibit *a*, nor would the removal of A defer the advent of *b*. In other words, regulation would be impossible. But, if we suppose that not the elemental act *a*, but rather

the sensory perception of A, the first state of the external construction, is the stimulus to *b* and, consequently, to the production of the second state of construction B, then we understand why *b* is released independently of *a*, when, for example, an insect discovers a ready-made substitute for A, the initial step in its construction, and we also understand why, in cases of accidental damage resulting in the total or partial removal of A, the reaction *b* is deferred and the reaction *a* prolonged, until the repair or reconstruction of A is complete; for, in this supposition, the addition of A will inhibit *a* and release *b*, whereas the subtraction of A will inhibit the appearance of *b* and consequently defer B, until the state of construction A, the sight of which is the stimulus to *b*, is complete. The fact of regulation, therefore, entails *sensory* control of the serial responses involved in the constructive instinct. Hence, as H. P. Weld of Cornell expresses it: "We may safely assume that even in the lowest forms of animal life some sort of sensory experience releases the (instinctive) disposition and to an extent determines the subsequent course of action." (Encycl. Am., v. 15, p. 168.)

But it would be going to the opposite extreme to interpret these adjustments of instinct to external contingencies as evidence of *intelligent* regulation. The animal's ability, for example, to repair accidental damage to a construction, which instinct impels it to build, is rigidly limited to repairs that can be accomplished by a simple continuation of the actual and normal occupation of the moment. If, however, the damage affects an already completed portion of the instinctive structure, and its present occupation is capable of continuance, the animal is impotent to relinquish this actual occupation of the moment, in order to cope with the emergency. Suppose, for illustration, that the instinctive operations *a* and *b* are finished and the animal is in the *c*-stage of its instinctive performance, then, if the damage is inflicted in the A-portion of the structure, and *c* can be continued independently of A, the animal cannot relinquish *c* and return to *a*, in order to restore the marred

integrity of A. This shows that the animal is guided, in its repair-work, by *sense,* which is bound to the here and now, and not by intelligence, which is an abstractive faculty that emancipates from the actual and concrete present, and enables the possessor to hark back to the past of its performance, should necessity require. Thus Fabre found that the Mason-bee, after it had turned from building to the foraging of honey and pollen, would no longer repair holes pricked in its cell, but suffered the latter to become a veritable vessel of the Danaïdes, which it vainly strove to fill with its liquid provender. Though the holes affected portions extremely close to the topmost layer of masonry, and although it frequently sounded and explored these unaccustomed holes with its antennæ, it took no steps to check the escape of the honey and pollen by recurring to its mason craft of earlier stages. And, finally, when it did resume the plasterer's trade in constructing a lid for the cell, it would spare no mortar to plug the gaping breaches in the walls of its cell, but deposited its egg in a chamber drained of honey, and then proceeded to perform the useless work of closing with futile diligence *only the topmost aperture* in this much perforated dwelling. Obviously, therefore, the bee failed to perceive the connection which existed between these breaches and the escape of the honey, and it was unable to apply its instinctive building skill to *new uses* by abstraction from the definite connection, in which the latter is normally operative.

Sense, therefore, and not intelligence, is the regulatory principle of instinct. To recognize causal and telic relationships is the prerogative of a superorganic intelligence. The transcendental link by which a useful means is referred to an ulterior end is something that cannot be *sensed,* but only *understood.* An animal, therefore, acts *toward* an end, not *on account of* an end. Nature, however, has compensated for this ignorance by implanting in each species of animal a special teleological disposition, by reason of which objects and actions, which are, under normal conditions, objectively use-

ful to the individual, or the species, become invested for the animal with a subjective aspect of agreeableness, while objects and actions, which are normally harmful, are invested with a subjective aspect of repulsiveness. The qualities of serviceableness and pleasantness *happen,* so far as the animal is concerned, to be united in one and the same concrete object or action, but the animal is only aware of the pleasantness, which appeals to its senses, and not of the serviceableness, which does not. Thus, in the example already cited, the dog suffering from tapeworms eats the herb known as Common Wormwood, not because it is aware of the remedial efficacy of the herb, but simply because the odor and flavor of the plant appeal to the animal in its actual morbid condition, ceasing to do so, however, when the latter regains the state of health. How different is the action of the man whose blood is infected with malarial parasites and who takes quinine, not because the bitter taste of the alkaloid appeals to his palate, but solely because he has his future cure explicitly in view! "Finally," says Weld, "the more we learn about instincts the more apparent it becomes that the situations from which they proceed are meaningful, but we need not suppose that the organism is aware of the meaning. The chick in the egg feels (we may only guess as to its nature) a vague discomfort, and the complicated reaction by which it makes its egress from the shell is released." (Encycl. Am., v. 15, p. 169.)

Recapitulating, then, we may define instinct as a psycho-organic propensity, not acquired by education or experience, but congenital by inheritance and identical in all members of the same zoölogical species, having as its physical basis the specific nervous organization of the animal and as its psychic basis a teleological coördination of the cognitive, emotional, and motor functions, in virtue of which, given the proper physiological state of the organism and the presence of an appropriate environmental stimulus, an animal, without consciousness of purpose, is impelled to the inception, and

regulated in the performance, of complicated behavior which is sensually gratifying and, under normal circumstances, simultaneously beneficial to the individual, or the race.

Instinctive acts are performed without previous experience or training on the part of the animal, and are, nevertheless, at least in the majority of cases, *perfect in their first performance.* A few, like the pecking-instinct of young chickens, are slightly improvable through sentient experience, *e.g.* the young chick, at first undiscriminating in the choice of the particles which it picks up, learns later by associative memory to distinguish what is tasty and edible from what is disagreeable and inedible, but, for the most part, the perfection of instinctive acts is independent of prior experience. Hence instinct is entirely different from human reason, which, in the solution of problems, is compelled to begin with reflection upon the data furnished by previous experience, or education. The animal, however, in its instinctive operations, without pausing to investigate, deliberate, or calculate, proceeds unhesitatingly on the very first occasion to a prompt and perfect solution of its problems. Hence, without study, consultation, planning, or previous apprenticeship of any sort, and in the complete absence of experimental knowledge, that might serve as matter for reflection or as a basis for inference, the animal is able to solve intricate problems in engineering, geometry, anatomy, pharmaceutics, etc., which the combined intelligence of mankind required centuries upon centuries of schooling, research, and reflection in order to solve. Of two things, therefore, one: either these actions do not proceed from an intelligent principle inherent in the animal; or they do, and in that case we are compelled to recognize in brute animals *an intelligence superior to our own,* because they accomplish deftly and without effort ingenious feats that human reason cannot duplicate, save clumsily and at the price of prolonged discipline and incessant drudgery. "Perhaps the strongest reason," says an anonymous writer, "for not regarding the activities of instinct

as intelligent is that in such enormously complex sequences of action as, for instance, the emperor moth carries out in the preparing of an escape-opening for itself on its completing the larval and passing into the imago state, the intelligence needed would be so great that it could not be limited to this single activity, and yet it is so limited." [4]

Intelligence is essentially a *generalizing* and *abstracting* power; hence, from its very nature, it could not be *limited to a single activity*. Bestial instincts, however, though frequently so amazingly complex and ingeniously purposive as to seem the fruit of profound meditation, are, nevertheless, confined exclusively to this or that determinate ability. They operate within narrow and preëstablished grooves, from which they never swerve to any appreciable degree, being but little modifiable or perfectible by experience. Bees always construct hexagonal cells, spiders stick to the logarithmic spiral, and beavers never attempt to put their engineering skill to new uses. Instincts have but little pliancy, their regularity and uniformity being such as to make the instinctive abilities definitely predictable in the case of any given species of animal. Now, the distinctive mark of intelligence is *versatility*, that is, aptitude for many things without determinate restriction to this or that. A man who is expert in one art may, by reason of his intelligence, be equally proficient in a dozen others. The biologist may be a competent chemist, and the astronomer an excellent physicist. Michel Angelo was a sculptor, a frescoer, a painter, an anatomist, an engineer, and an architect, while Leonardo da Vinci had even more arts to his credit. To predict before birth the precise form that a man's ability will take is an impossibility. Certain aptitudes, such as a musical gift, are no doubt inherited, but it is an inheritance which imposes no rigid necessity upon inheriter; since he is free to neglect this native talent, and to develop others for which he has no special innate aptitude. With man, the fashion in clothing and the styles of archi-

[4] Cf. Nelson's Encyclopedia, v. 6, p. 452.

tecture vary from day to day. The brute, however, never emerges from the rut of instinct, and each generation of a given animal species monotonously reproduces the history of the previous generation. Man, on the contrary, is capable of indefinite *progress*, as the march of human cultures and civilizations shows. Gregarious animals are restricted by their instincts to determinate types of aggregation, as we see in the case of ants and bees. Hence these insect communities are unacquainted with our sanguinary revolutions which overturn monarchies in favor of republics, or set up dictatorships in place of democracies; for, fortunately or unfortunately, as one may choose to regard it, man is not limited to one form of government rather than another.

Animals, then, notwithstanding their wonderful instincts, are deficient in precisely that quality which is the unique criterion of intelligence, namely, versatility. Each species has but one stereotyped ability, outside of which it is woefully stupid and inefficient. "So long," says Fabre, "as its circumstances are normal the insect's actions are calculated most rationally in view of the object to be attained" ("The Mason-Bees," p. 167), but let the circumstances cease to be normal, let them vary never so little from those which ordinarily obtain, and the animal is helpless, while its instinctive predisposition becomes, not merely futile, but often positively detrimental. Thus the instinct, which should, in the normal course of events, guide night-flying moths to the white flowers that contain the life-sustaining nectar of their nocturnal banquets, proves their undoing, when they come into contact with the white lights of artificial illumination. In fact, the fatal fondness of the moth for the candle flame has become in all languages a proverb for the folly of courting one's own destruction.

The animal may employ an exquisitely efficient method in accomplishing its instinctive work, but is absolutely impotent to apply this ingenious method to more than one determinate purpose. Man, however, is not so restricted. He

varies at will both his aims and his methods. He can adapt the *same means* (a pocketknife, for instance) to *different ends,* and, conversely, he can obtain the *same end* by the use of *different means* (*e.g.* communicate by mail, or telegraph, or radio). Man, in a word, is *emancipated from limitation to the singular and the concrete* by virtue of his unique prerogative, reason, or intelligence, the power that enables him *to generalize from the particular and to abstract from the concrete.* This is the secret of his unlimited versatility. This is the basis of his capacity for progress. This is the root of his freedom; for his will seeks happiness in general, happiness in the abstract, and is not, therefore, compelled to choose any particular form or concrete embodiment of happiness, such as this or that style of architecture, this or that form of government, this or that kind of clothing, etc., etc. Teleology is but a material expression of intelligence, and may, therefore, occur in things destitute of intelligence, but versatility is the inseparable concomitant and infallible sign of an inherent and autonomous intelligence. Lacking this quality, instinct, however telic, is obviously not intelligence.

Another indication of the fact that no intelligence lies behind the instinctive behavior of brutes is manifest from their evident *unconsciousness of purpose.* That the animal is ignorant of the purpose implied in its own instinctive actions appears from the fact that it will carry out these operations with futile diligence and exactitude, even when, through accident, the purpose is conspicuously absent. Thus the hen deprived of her eggs will, nevertheless, continue the now futile process of incubation for twenty-one days, or longer, despite the fact that her obstinacy in maintaining the straw of the empty nest at a temperature of 104° F. serves no useful purpose whatever. She cannot but sense the absence of the eggs; she has not, however, the intelligence to realize that incubation without eggs is vain. The connection between the latter and the former is something that mere sense cannot apprehend. Hence the hen is not troubled by the pur-

poselessness of her performance. Fabre gives many examples of this futile persistence in instinctive operations, despite their complete frustration. Alluding to the outcome of his experiments on the Mason-wasp *Pelopaeus*, he says: "The Mason-bees, the Caterpillar of the Great Peacock Moth, and many others, when subjected to similar tests, are guilty of the same illogical behaviour: they continue, in the normal order, their series of industrious actions, though accident has now rendered them all useless. Just like millstones unable to cease revolving though there be no corn left to grind, let them once be given the compelling power and they will continue to perform their task despite its futility." ("Bramble Bees," pp. 192, 193.)

The instance cited by Dr. H. D. Schmidt is an excellent illustration of this inability of an animal to appreciate either the utility or futility of its instinctive behavior. Having described the instinct of squirrels to bury nuts by ramming them into the ground with their teeth, and then using their paws to cover them with earth, he continues as follows: "Now, as regards the young squirrel, which, of course, never had been present at the burial of a nut, I observed that, after having eaten a number of hickory nuts to appease its appetite, it would take one between its teeth, then sit upright and listen in all directions. Finding all right, it would scratch upon the smooth blanket on which I was playing with it as if to make a hole, then hammer with the nut between its teeth upon the blanket, and finally perform all the motions required to fill up a hole—*in the air;* after which it would jump away, leaving the nut, of course, uncovered." (*Transactions of the Am. Neurological Ass'n,* 1875, vol. I, p. 129—italics his.) This whole pantomime of purposeless gesticulations, from the useless "Stop, look and listen!" down to the final desertion of the uncovered nut, is overwhelming evidence of the fact that the brute is destitute of any rational faculty capable of recognizing the telic aspect of its own instinctive conduct.

The claim is sometimes made that certain forms of animal behavior are not unconsciously, but *consciously,* telic. Bouvier,

for example, claims that in the rare cases of the *use of tools* among the Arthropoda, we have evidence of the existence of intelligent inventiveness of a rudimentary kind. Thus the crab *Melia* carries a sea-anemone in its chela as a weapon wherewith to sting its prey into a condition of paralysis. The leaf-cutting ants of India and Brazil use their own thread-spinning larvæ as tools for cementing together the materials out of which their nests are constructed. The predatory wasp *Ammophila urnaria* uses a pebble to tamp the filling of its burrow. According to the Wheelers (cf. *Science*, May 30, 1924, p. 486), the hunting wasp *Sphex* (*Ammophila*) *gryphus* (Sm.) makes similar use of a pebble. As Bouvier notes, however, this use of tools appears "to be rather exceptional . . ., showing itself only in the primitive state consisting of the use of foreign bodies as implements." (Smithson. Inst. Rpt. for 1918, p. 456.) Moreover, the animals in question are limited to a concretely determinate kind of tool, which their environment supplies ready-made. Such a use of implements *does not presuppose any power of abstraction and generalization.* In fact, the presence of such a power is expressly excluded by the consideration that the animal's so-called "inventiveness" is confined exclusively to *one particularized manifestation.*

At times the behavior of animals so closely simulates the consciously telic or intelligent conduct of men, that only severely critical methods enable us to discriminate between them. An experiment, which Erich Wasmann, S.J., performed upon ants will serve to illustrate this point. In one of his glass nests, Father Wasmann constructed an island of sand surrounded by a moat filled with water. He then removed from their "nursery" a certain number of the ant larvæ and placed them on the island. Thereupon the ants were observed to build a bridge of sand across the moat "for the purpose," apparently, of rescuing the marooned larvæ. Such behavior seemed to imply an intelligent ordination of a means to an end. Wasmann's second experiment, however, proved this inference to be wholly unwarranted;

for, when he excavated a hole in the sand of the nest and filled it with water, the ants, stimulated by what to them was the disagreeable dampness of the marginal sand, were impelled to perform the reflex act of kicking about in the sand. This impulse persisted until all traces of the hole, the dampness and the water had been buried under a carpet of drier sand. Then, and then only, was the aforesaid impulse inhibited. Applying these results to the interpretation of the first experiment, we see that the "building of a bridge" in the first experiment was not intentional, but merely an accidental result of a kicking-reflex, with damp sand acting as a stimulator. Once the moat was bridged, however, the ants happened to find the larvæ, and were then impelled by instinct to carry the larvæ to their proper place in the nest. To see in such an incident a planned and premeditated rescue of the marooned larvæ would be grossly anthropomorphic. Nevertheless, had only the first experiment been performed, such an anthropomorphic interpretation would have seemed fully justified, and it was only by an appropriate variation of the conditions of the original experiment that this false interpretation could be definitively excluded.

Consciously telic behavior is distinguishable from unconsciously telic conduct only to the extent that it implies an agent endowed with the power of abstraction. Unless an agent can vary radically the specificity of the procedure, whereby it attains a given end, the purposiveness of its behavior is no evidence of its intelligence. "Among animals," says Bergson, "invention is never more than a variation on the theme of routine. Locked up as it is within the habits of its species, the animal succeeds no doubt in broadening these by individual initiative; but its escape from automatism is momentary only, just long enough to create a new automatism; the gates of its prison close as soon as they are opened; dragging the chain merely lengthens it. Only with man does consciousness break the chain." (Cf. Smithson. Inst. Rpt. for 1918, p. 457.)

In vain, then, do our Darwinian humanizers of the brute exalt instinct at the expense of intelligence. Their attempt to reduce to a difference of degree the difference of kind that separates the irrational from the rational, fails all along the line. Indeed, far from being able to account for the appearance of intelligence in the world, transformistic theories are impotent to account for so much as the development of instinct, all forms of the evolutionary theory, the Lamarckian, the Darwinian, the De-Vriesian, etc., being equally inadequate to the task of explaining the origin of animal instincts.

The complex instinctive behavior of predatory wasps, for example, is absolutely essential for the preservation of their respective races, and yet these indispensable instincts are completely useless in any other than the *perfect state*. From their very nature, therefore, they do not admit of *gradual development*. The law of all, or none, holds here. "Instinct developed by degrees," says Fabre, "is flagrantly impossible. The art of preparing the larva's provisions allows none but masters, and suffers no apprentices; the Wasp must excel in it from the outset or leave the thing alone." ("The Hunting Wasps," p. 403.) To be useful at all, the instinctive operation must possess an indivisible perfection, which cannot be partitioned into degrees. The *Pompilius* (*Calicurgus*), for instance, must, under penalty of instant death, take the preliminary precaution to sting into inaction the ganglion that controls the poison forceps of her formidable prey, the Black Tarantula (*Lycosa*), before she proceeds to paralyze it by stabbing its thoracic ganglion. The slightest imperfection or shortcoming in her surgery would be irretrievably disastrous. Such an instinct never existed in an imperfect form. The first wasp to possess it must have been an expert, or she would never have lived to serve the limp body of the huge spider as living provender for her tiny grub. "The first to come to grips with the Tarantula," says Fabre, "had an unerring knowledge of her dangerous surgery. The least hesitation, the slightest

speculation, and she was lost. The first teacher would also have been the last, with no disciples to take up her art and perfect it." ("Bramble Bees," p. 354.)

Another hunting wasp, the Hairy Ammophila, subdues a large caterpillar into a state of coma by pricking with its sting nine of the ventral ganglia, while it spares the cervical ganglion, merely compressing the latter with its mandibles, so as not to destroy life altogether. This nice discrimination rules out Loeb's hypothesis of a so-called "chemotaxis." As a result of this elaborate surgical operation, the power of movement is suppressed in every segment, and the tiny larva of the wasp emerging from the egg laid on the ventral surface of the caterpillar can devour this huge living, but motionless, victim in peace and safety. Dead meat would not agree with the larva, and any movement of the caterpillar would be fatal to the delicate grub. To eliminate these contingencies, the Wasp's surgery must be perfect from the very outset. "There is," says Fabre, "no *via media*, no half success. Either the caterpillar is treated according to rule and the Wasp and its family is perpetuated; or else the victim is only partially paralyzed and the Wasp's offspring dies in the egg. Yielding to the inexorable logic of things, we will have to admit that the first Hairy Ammophila, after capturing a Grey Worm to feed her larva, operated on the patient by the exact method in use today." ("The Hunting Wasps," pp. 403, 404.)

Certain meticulous critics of our day cite the fact of the diffusion of the poison as indicating that the surgery of the hunting wasps need not be so perfectly accommodated to the nervous system of their prey, and they attempt in this way to discredit Fabre as having failed to take the occurrence of diffusion into account. A careful reading of his works, however, will serve to vindicate him in this respect. In a chapter on the poison of the bee, for instance, we read: "The local effect is diffused. This diffusion, which might well take place in the victims of the predatory insects, plays no part in the latter's method of operation. The

egg, which will be laid immediately afterwards, demands the complete inertia of the prey from the outset. Hence all the nerve-centers that govern locomotion must be numbed instantaneously by the virus." ("Bramble Bees," p. 347.) Bouvier, therefore, very justly remarks: "After all, when Fabre's work is examined there is no trouble in seeing that none of these details escaped him. He never disputed the paralytic action of the poison inoculated by the insect, and the wonderful researches by the Peckhams on the Pompilids, which hunt Lycosids, have clearly established the fact that the thrusts of the sting given by the predatory insect produce two different kinds of paralysis, one functional, and often temporary, resulting from the action of the venom, the other structural and persistent, produced by the dart which more or less injures the nervous centers." (Smithson. Inst. Rpt. for 1916, p. 594.)

In the case of predatory insects, therefore, the instinct must be *perfect at the outset,* or survival is impossible. For the origin of such instincts, Darwinism, which stresses the *gradualness* of evolutionary progress, has no explanation that will hold water. Lamarckism, which sees in *acquired habits* transmitted by inheritance, the origin of instinct, the "memory of the race," is equally at a loss to account for these instincts. The formation of habits requires *practice* and *repetition.* The predatory insect must be perfect at the start, and yet it only exercises its remarkable instinct *once a year.* Where is the practice and reiteration requisite for canalizing its nervous system into the conduction-paths of habit? How did one particular set of rarely performed acts happen to gain precedence over all others, and to be alone successful in stamping themselves indelibly upon the nerve plasm as habits, and upon the germ plasm as instincts? De-Vriesianism, which would make the acquisition and perfecting of instinct dependent upon the rare and accidental contingency of a *fortuitous mutation,* is even more objectionable. These instincts are vital to the insect. If their acquisition and improvement depend upon the lucky chance of a series of favorable mutations, its prospects of

survival are nil; for it cannot afford to wait at all. "In order to live," says Fabre, "we all require the conditions that enable us to live: this is a truth worthy of the famous axioms of La Palice. The predatory insects live by their talent. If they do not possess it to perfection, their race is lost." ("Bramble Bees," p. 364.)

Recently, there has been a revival of Lamarckism hitherto regarded as defunct. Guyer, Kammerer, and Pawlow profess to find factual justification for it, and Bouvier adopts it in his "La vie psychique des insectes" (1918), to account for the origin of instinct. Of the alleged facts of Kammerer and Guyer, we have spoken in a previous chapter. Here we shall content ourselves with few remarks on the experiments of Ivan Pawlow, as being especially relevant to the subject under consideration. The Russian physiologist has experimented on white mice, and claims that the mice of the fifth generation learned to answer a dinner bell in the space of five lessons, whereas their ancestors of the first generation had required a hundred lessons to answer the same signal. Hence he concludes: "The latest experiments . . . show that conditioned reflexes, *i.e.*, the highest nervous activity, are inherited." (*Science*, Nov. 9, 1923, p. 360.) His results, however, do not tally with those recently obtained by E. C. MacDowell of the Carnegie Institution, by H. G. Bragg, and by E. M. Vicari of Columbia. MacDowell found that white rats trained in a circular maze did not improve in their susceptibility to training from generation to generation. "Children from trained parents," he says, "or from trained parents and grandparents, take as long to learn the maze habit as the first generation used." (*Science*, March 28, 1924, p. 303.) Having cited the similar results of Bragg, who experimented with white mice, he concludes: "The results are in full accord with those given above; they indicate that the training of the ancestors did not facilitate the learning of the descendants." (*Ibidem.*) E. M. Vicari, using a simple maze and white rats, obtained the same results. "It seems clear," she says, "that the latter

generations have not been aided by the training of their ancestors." (*Ibidem.*)

Bouvier's conception, then, that the automatisms of instinct originate as automatisms of acquired habit, the latter being appropriated by inheritance, still stands in need of reliable experimental confirmation. Moreover, a theory of this sort could never account, as Weismann points out, for such phenomena as the specific instincts of worker bees, which are *excluded from propagation.* Nor can the theory explain, as originating in acquired *habit,* those instinctive operations of enormous complexity, like the complicated method of emergence employed by the larva of the emperor moth, which only occur *once in a lifetime,* and could not, therefore, fasten themselves on the organism as a *habit.*

An evolutionary origin of instinct, however, though extremely improbable, is, at any rate, not absolutely inconceivable. Its teleology, as we have seen, does not imply inherent intelligence, but is explicable as an innate law involving appropriate coördination of the sensory, emotional, and motor functions, all of which are intrinsically dependent on the organism. But intelligence, as we have seen, is a superorganic power, having its source in a spiritual principle, that, from the very nature of things, cannot be evolved from matter. Human reason, therefore, owes its origin, not to any evolution of the human body, but to the creation of the human soul, which is the source and subject of that unique prerogative of man, namely: the power of abstract thought.

CHAPTER III

THE ORIGIN OF THE HUMAN BODY

In an article published August 31, 1895, in the *New York Freeman's Journal*, the late Rev. J. A. Zahm gave expression to the following opinion: "The evolution of the body of man from some inferior animal and its subsequent endowment in this body by God of a rational soul is antagonistic to no dogma of faith and may be shown to be in harmony with the teachings of St. Thomas." The scriptural and theological aspect of this view need not concern us here, our sole purpose being to evaluate it from a purely scientific standpoint. Once evolutionary thought takes cognizance of the fact that the human soul is a spiritual principle underivable from mere matter, once it acknowledges the immediate creation of the human soul, and professes to do no more than account for the origin of man's animal *body*, that moment is it shorn of its materialistic implications; but what, we may ask, are the foundations of such an hypothesis in the realm of scientific fact?

The writer must confess that he cannot fathom the mentality of those who accept the evolutionary explanation, so far as plant and animal organisms are concerned, but proceed to draw the line when it comes to applying it to the human body. For if one (to borrow Du Bois-Reymond's expression) "gives so much as his little finger to" the evolutional argument from organic homology, he must end, in so far as he is consistent, in acknowledging as incontestable its obvious application to man. The only choice which sound logic can sanction is between fixism and a thoroughgoing system of transformism, which does not exempt the human body from the scope of the

evolutionary explanation. Indeed, the theory of evolution itself stands or falls upon this issue; for, if structures so strikingly similar as the skeletons of a man and an ape, respectively, have originated from two distinct ancestral stocks, then in no case at all is the inference of common descent from structural resemblance a legitimate procedure. In other words, if the homologies existent between the human and simian organisms are explicable on some other basis than that of common ancestry, then all organic homologies are so explicable, and the whole evolutionary argument collapses.

§ 1. Two Theories of Descent

Two theories have been formulated regarding the alleged bestial origin of the human body: (1) the theory of lineal descent from some known species (living or fossil) of ape or monkey; (2) the theory of collateral descent from a hypothetical bestial ancestor common to apes and men. The theory of lineal descent is that to which Darwin himself stands committed. This theory, however, soon fell into disrepute among scientists, who came to prefer the theory of collateral descent, although signs of a return to the older theory are not wanting in our day. At all events, Darwin came out flatly in favor of the monkey origin of man. This, it is true, has been indignantly denied by loyal partisans anxious to exonerate their idol from the reproach of having advanced a crude and now obsolete theory of human descent. But Darwin's own words speak for themselves: "The Simiadae," he says, "then branched off into two great stems, the New World and Old World monkeys; and from the latter, at a remote period of time, Man, the wonder and glory of the Universe, proceeded." ("Descent of Man," 2nd ed., ch. VI, pp. 220, 221.) Note that he does not say "probably"; his language is not the language of hypothesis, but of categorical affirmation.

The theory, however, which is most generally favored at the present time holds that, assuming the universality of the evo-

lutionary process, all existing types must be of equal antiquity, and none prior or ancestral to any other. Hence it regards man, not as the direct descendant of any known type of ape, but as the offspring of an as yet undiscovered Tertiary ancestor, from which men and apes have diverged in two distinct lines of descent. "*Monkeys, apes, and men,*" says Conklin, "*have descended from some common but at present extinct ancestor.* Existing apes and monkeys are collateral relatives of man but not his ancestors; his cousins but not his parents. . . . The human branch diverged from the anthropoid stock not less than two million years ago, and since that time man has been evolving in the direction represented by existing human races, while the apes have been evolving in the direction represented by existing anthropoids. During all this time men and apes have been growing more and more unlike and conversely the farther back we go, the more we should find them converging until they meet in a common stock which should be intermediate between these two stocks." ("Evolution and the Bible," pp. 12, 13—italics his.)

Barnum Brown's recent discovery of three jaws of the fossil ape *Dryopithecus* in the Siwalik Hills of India has, as previously intimated, resulted in a return on the part of certain scientists, *e.g.* Wm. K. Gregory and Dudley J. Morton, to views that more nearly approximate those of Charles Darwin. According to these men, the fossil anthropoid *Dryopithecus* is to be regarded as the common ancestor of men, chimpanzees, and gorillas. (Cf. *Science,* April 25, 1924, Suppl. XII.)

Many considerations, however, militate against the direct derivation of man's bodily frame from any known species of ape, whether living or fossil. Dana has pointed out that, as regards the mechanism of locomotion, man belongs to a more primitive type than the ape. The earliest and lowest type of vertebrates are the fish, and these, according to the above-mentioned author, are *urosthenic* (tail-strong), inasmuch as they propel themselves by means of their tails. Next in point of organization and time came the *merosthenic* vertebrates,

which have their strength concentrated in the hind-limbs, *e.g.* reptiles like the dinosaurs. In the last place come the *prosthenic* vertebrates, whose strength is concentrated in the fore-limbs, *e.g.* the carnivora and apes. Now man belongs to the *merosthenic* type, and his mode of progression, therefore, is more primitive than that of apes, which are *prosthenic,* all anthropoid apes, such as the gorilla, the chimpanzee, the orang-utan and the gibbon having longer fore-limbs than hind-limbs.

The striking anatomical differences between apes and men, though not of sufficient importance to exclude the possibility of collateral relationship, are so many solid arguments against the theory of direct descent. We will content ourselves with a mere enumeration of these differences. In the ape, the cranium has a protruding muzzle and powerful jaws equipped with projecting canine teeth, but the brain-case is comparatively small; in man, on the contrary, the facial development is insignificant and the teeth are small and vertical, while the brain-case is enormous in size, having at least twice the capacity of that of an ape. "The face of man," to quote Ranke, "slides, as it were, down from the forehead and appears as an appendix to the front half of the skull. But the gorilla's face, on the contrary, protrudes from the skull, which in turn slides almost entirely backward from the face. By a cross-cut one may sever the whole face from the skull, except a very small part near the sockets, without being forced to open up the interior of the skull. It is only on account of its protruding, strongly developed lower parts that the skull-cap of the animal can simulate a kind of human face." ("Der Mensch," vol. II, p. 401.) These differences may be summarized by saying that the head of the ape is specialized for mastication and defense, whereas the head of man is specialized for psychic functions. Again, as we have seen, the fore-limbs of the ape are long, and its hind-limbs short, the extremities of both the latter and the former being specialized primarily for prehension and only secondarily for progression. This is due to the ape's adaptation to arboreal life. In man, however,

the arms are short and specialized for prehension alone, while the legs are long and terminate in broad plantigrade feet specialized for progression alone. Man, consequently, is not adapted to arboreal life. In the ape, the spine has a single curve, and the occipital foramen (the aperture through which the spinal cord enters the brain-case) is eccentrically located in the floor of the cranial box; in man, the spine has a double curve, and the occipital foramen is centrally located, both features being in adaptation to the upright posture peculiar to man—*"die zentralle Lage dieser Oeffnung,"* says Ranke alluding to the occipital foramen of man, *"in der Schädelbasis ist für den Menschenschädel im Unterschied gegen den Tierschädel eine in hohem Masse typische."* ("Der Mensch," vol. I, p. 378.) In the ape, therefore, the vertebræ have an adaptation producing convexity of the back, precluding a normal upright posture, and enforcing progression on all fours. It has, moreover, powerful muscles at the back of the neck to carry the head in the horizontal position necessitated by this mode of progression. In man "the skull has the occipital condyles placed within the middle fifth, in adaptation to the vertical position of the spine" (Nicholson), the spinal cord enters the cranial box at a perpendicular, and the head balances on the spinal column as on a pivot, all of which ensures the erect posture and bipedal progression in man. There are, moreover, no neck muscles to support the head in any other than the vertical position. There are many other differences, besides: the ape, for example, has no chin, while in man there is a marked mental protuberance; man has a slender waist, but the ape has a barrel-like torso without any waist; the ape has huge bony ridges for the attachment of muscles, *e.g.* the sagittal crest, the superciliary ridges, etc., while in man such features are practically absent.

Ranke has given a very good summary of the chief anatomical differences between man and the anthropoid apes: "The gorilla's head leaning forward, hangs down from the spinal column, and his chinless snout, equipped with powerful teeth,

touches the breastbone. Man's head is round, and resting on a free neck, balances unrestrained upon the spinal column. The gorilla's body, without a waist, swells out barrel-shaped, and when straightened up finds no sufficient support on the pelvis; the back-bone, tailless as in man, but almost straight, loses itself without nape or neck formation properly so-called in the rear part of the head and without protuberance of the gluteal region in the flat thighs. Man's body is slightly molded, like an hour-glass, the chest and abdomen meeting to form a waist where they are narrowest; the abdominal viscera are perfectly supported in the pelvis as in a plate; and elegance is decidedly gained by the double S-line, which, curving alternately convex and concave, passes from the crown through the neck and nape, down the back to the base of the spine and the gluteal region. The normal position of the gorilla shows us a plump, bear-like trunk, carried by short, crooked legs and by arms which serve as crutches and touch the ground with the knuckles of the turned-in fingers. The posture of the body is perfectly straight in man, it rests on the legs as on columns when he stands upright, and his hands hang down on both sides always ready for use. The gorilla is thickly covered with hair, while man's body on the whole is naked." (*Op. cit.*, vol. II, p. 213.)

In conclusion, we may say that, while there is a general resemblance between the human body and that of an anthropoid ape, there is, likewise, a particular divergence—"there is no bone, be it ever so small, nay, not even the smallest particle of a bone, in which the general agreement in structure and function would pass over into real identity." (Ranke, *op. cit.*, vol. I, p. 437.) Hence Virchow declares that "the differences between man and monkey are so wide that almost any fragment is sufficient to diagnose them." (Smithson. Inst. Rpt. for 1889, p. 566.) These differences are so considerable as to preclude the possibility of a *direct* genealogical connection between man and any known type of ape or monkey—"The testimony of comparative anatomy," to quote Bumüller, "is

decidedly against the theory of man's descent from the ape." ("Mensch oder Affe?" p. 59.) Ranke has somewhere called man a brain-animal, and this sums up the chief difference, which marks off the human body from all bestial organisms. In the ape the brain weighs only 100th part of the weight of its body, whereas in man the brain has a weight equivalent to the 37th part of the weight of the human body. The cranial capacity of the largest apes ranges from 500 to 600 c.cm., while the average cranial capacity in man is 1500 c.cm. Moreover, the human brain is far more extensively convoluted within the brain-case than that of an ape, so much so that the surface or cortical area of the human brain is four times as great as that of the ape's brain. Thus Wundt, in his "Grundzüge der physiologischen Psychologie," cites H. Wagner as assigning to man a brain surface of from 2,196 to 1,877 sq. cm., but a cortical area of only 535 sq. cm. in the case of an orang-outang. (Cf. English Translation by Titchener, vol. I, p. 286.)

Another difficulty in the way of the Darwinian theory of direct descent is the fact that the best counterparts of human anatomy are not found united in any one species of ape or monkey, but are scattered throughout a large number of species. "Returning to the old discussion," says Thomas Dwight, "as to which ape can boast of the closest resemblance to man, Kohlbrugge brings before us Aeby's forgotten book on the skull of man and apes. His measurements show that the form nearest to man among apes is the gibbon, or long-armed ape, but that the South American monkey *Crysothrix* is nearer still. Aeby recognized what modern anatomists have forgotten or wilfully ignored: that any system of descent is inadequate which does not recognize that the type of man is not in any one organ, but in all the physical and psychological features. He declared that while we are far from having this universal knowledge, we have learned enough about the various parts of the body to make it impossible for us to sketch any plan of descent. 'It almost seems as if every part

had its own line of descent, different from that of others.' . . . Kohlbrugge now introduces Haacke, who denies any relationship between man and apes, the latter being instances of one-sided development. He even dares to declare anyone who speaks of an intermediate form between man and apes to be ignorant of the laws of development governing the race history of mammals. He believes man came from some lemuroid form, which may have descended from the insectivora." ("Thoughts of a Catholic Anatomist," pp. 188-190.)

All known types, then, of apes and monkeys are too specialized to have been in the direct line of human descent. Man, as Kohlbrugge ironically remarks, appears to have come from an ancestor much more like himself than any species of ape we know of. Moreover, no species of apes or monkeys monopolizes the honors of closest resemblance to man. In many points, the South American monkeys, though more primitive than the anthropoid apes, are more similar to man than the latter.

§ 2. **Embryological Resemblances**

Much has been made of the so-called biogenetic law as an argument for the bestial origin of mankind. This theory of the embryological recapitulation of racial history was first formulated by Fritz Müller. Haeckel, however, was the one who exploited it most extensively, and who exalted it to the status of "the fundamental law of biogenesis." [1] The latter's statement of the principle is as follows: *"Die Ontogenesis ist die Palingenesis der Phylogenesis."*—Ontogeny (the development of the individual) is a recapitulation of phylogeny (the development of the race). For a long time this law was received with uncritical credulity by the scientific world, but enthusiasm diminished when more careful studies made it clear that the line of descent suggested by embryology did

[1] Haeckel's "Biogenetisches Grundgesetz," which he formulates thus: *"Die Ontogenie (Keimesgeschichte) ist eine kurze Wiederholung der Phylogenie (Stammegeschichte),"* 1874.

not agree with what was inferred from comparative anatomy and the sequence of fossil forms. Besides, it was manifest that certain organs in embryos were distinctively *embryonic* and could never have functioned in adult forms, *e.g.* the yolk sac and the amnion. "It was recognized," says T. H. Morgan, "that many embryonic stages could not possibly represent ancestral animals. A young fish with a huge yolk sac attached could scarcely ever have led a happy, free life as an adult individual. Such stages were interpreted, however, as *embryonic* additions to the original ancestral type. The embryo had done something on its own account. In some animals the young have structures that attach them to the mother, as does the placenta of mammals. In other cases the young develop membranes about themselves—like the amnion of the chick and the mammal—that would have shut off an adult animal from all intercourse with the outside world. Hundreds of such embryonic structures are known to embryologists. These were explained as adaptations and as falsifications of the ancestral records." ("Critique of the Theory of Evolution," pp. 16, 17.)

The result has been that this so-called law has fallen into general disrepute among scientists, especially as a means of reconstructing the phylogeny of modern organisms. It is recognized, of course, that comparative embryology can furnish embryological homologies analogous to the homologies of comparative anatomy, but it is now generally acknowledged that the view, which regards the embryological process as an abridged repetition of the various states through which the species has passed in its evolutionary career must be definitively abandoned, and that, as a general law of organic development, the biogenetic principle has been thoroughly discredited. "This law," says Karl Vogt of Geneva, "which I long held as well-founded, is absolutely and radically false. Attentive study of embryology shows us, in fact, that embryos have their own conditions suitable to themselves, and very different from those of adults." (Quoted by Quatrefages De Breau, in his

"Les Emules de Darwin," vol. II, p. 13.) "There can no longer be question," says Prof. M. Caullery of the Sorbonne, "of systematically regarding individual development as a repetition of the history of the stock. This conclusion results from the very progress made under the inspiration received from this imaginary law, the law of biogenesis." (Smithson. Inst. Rpt. for 1916, p. 325.)

This collapse of the biogenetic law has tumbled into ruins the elaborate superstructure of genealogy which Haeckel had reared upon it. His series of thirty stages extending from the fictitious "cytodes" up to man, inclusively, is even more worthless to-day than it was when Du Bois-Reymond made his ironic comment: "Man's pedigree, as drawn up by Haeckel, is worth about as much as is that of Homer's heroes for critical historians." (*Revue Scientifique*, 1877, I, p. 1101.) Haeckel tried in vain to save his discredited law by means of the expedient of *cœnogenesis*, that is, "the falsification of the ancestral record (palingenesis)." That Nature should be guilty of "falsification" is an hypothesis not to be lightly entertained, and it is more credible, as Wasmann remarks, to assume that Haeckel, and not Nature, is the real falsifier, inasmuch as he has misrepresented Nature in his "fundamental biogenetic law." Cœnogenesis is a very convenient device. One can alternate at will between *cœnogenesis* and *palingenesis*, just as, in comparative anatomy, one can alternate capriciously between *convergence* and *homology*, on the general understanding of its being a case of: "Heads, I win; tails, you lose"—certainly, there is no *objective* consideration to restrain us in such procedure. "Such weapons as Caenogensis and Convergence," says Kohlbrugge (in his "Die Morphologische Abstammung des Menschen," 1908) "are unfortunately so shaped that anyone can use them when they suit him, or throw them aside when they do not. They show, therefore, in the prettiest way the uncertainty even now of the construction of the theory of descent. As soon as we go into details it leaves us in the lurch; it was only while our knowledge was small that every-

thing seemed to fit together in most beautiful order." (Quoted by Dwight in "Thoughts of a Catholic Anatomist," p. 187.)

It is undeniable, indeed, that in many cases the young of higher animals pass through stages in which they bear at least a superficial resemblance to adult stages in inferior and less complex organisms. Obviously, however, there cannot be any direct derivation of the *embryonic* features of one organism from the *adult* characters of another organism. This preposterous implication of the Müller-Haeckel Law must, as Morgan points out, be entirely eliminated, before it can merit serious consideration. Referring to the spiral cleavage exhibited by annelid, planarian and molluscan eggs, Morgan says: "It has been found that the cleavage pattern has the same general arrangement in the early stages of flat worms, annelids and molluscs. Obviously these stages have never been adult ancestors, and obviously if their resemblance has any meaning at all, it is that each group has retained the same general plan of cleavage possessed by their common ancestor. . . . Perhaps someone will say, 'Well! is not this all that we have contended for! Have you not reached the old conclusion in a roundabout way?' I think not. To my mind there is a wide difference between the old statement that the higher animals living today have the original adult stages telescoped into their embryos, and the statement that the resemblance between certain characters in the embryos of higher animals and corresponding stages in the embryos of lower animals is most plausibly explained by the assumption that they have descended from the same ancestors, and that their common structures are embryonic survivals." (*Op. cit.*, pp. 22, 23.)

After this admission, however, nothing remains of the law of "recapitulation" except simple embryological homology comparable, in every sense, to adult homology, and adding nothing essentially new to the latter argument for evolution. It is, therefore, ridiculous for evolutionists to speak of *branchial* (gill) arches and clefts in man. The visceral or pharyngeal arches and grooves appearing in the human embryo are

unquestionably homologous with the genuine branchial arches and clefts in a fish embryo. In the latter, however, the grooves become real clefts through perforation, while the arches become the lamellæ of the permanent gills, thus adapting the animal to aquatic respiration. It is, accordingly, perfectly legitimate to refer to these embryonic structures in the young fish as gill arches and gill clefts. In man, however, the corresponding embryonic structures develop into the oral cavity, auditory meatus, ossicles of the ear, the mandible, the lower lip, the tongue, the cheek, the hyoid bone, the styloid process, the thymus, the thyroid and tracheal cartilages, etc. There is no perforation of the grooves, and the arches develop into something quite different than branchial lamellæ. Hence the correct name for these structures in the human embryo is *pharyngeal* (visceral) arches and grooves, their superficial resemblance to the embryonic structures in the fish embryo being no justification for calling them branchial. In short, the mere fact that certain embryonic structures in the young fish (homologous to the pharyngeal arches and grooves in the human embryo) develop into the permanent gills of the adult fish, is no more significant than the association of homology with divergent preadaptations, which is of quite general occurrence among adult vertebrate types. In all such cases, we have instances of fundamentally identical structures, diverted, as it were, to entirely different purposes or functions (*e.g.* the arm of a man and the flipper of a whale). Hence the argument drawn from embryological homology is no more cogent than the argument drawn from the homologies of comparative anatomy, which we have already discussed in a previous chapter. The misuse of the term *branchial,* to prejudge matters in their own favor, is in keeping with the customary policy of evolutionists. It is intended, naturally, to convey the impression that man, in the course of his evolution, has passed through a fish-like stage. At bottom, however, it is nothing more than a verbal subterfuge, that need not detain us further.

The theory of embryological recapitulation is often applied

to man, with a view to establishing the doctrine of his bestial ancestry. We have seen one instance of this application, and we shall consider one other, for the purpose of illustrating more fully the principles involved. The claim is made by evolutionists, that man must have passed through a fish or amphibian stage, because, in common with all other mammals, he exhibits, during his embryological development, a typical fish (or, if you prefer, amphibian) kidney, which subsequently atrophies, only to be replaced by the characteristic mammalian kidney. The human embryo, therefore, repeats the history of our race, which must have passed through a fish-like stage in the remote past. In consequence of this phenomenon, therefore, it is inferred that man must have had fish-like ancestors. Let us pause, however, to analyze the facts upon which this inference is based.

In annelids, like the earthworm, the nephridia or excretory tubules are arranged segmentally, one pair to each somite. In vertebrates, however, the nephridial tubules, instead of developing in regular sequence from before backwards, develop in three batches, one behind the other, the anterior batch being called the *pronephros,* the middle one, the *mesonephros* and the posterior one, the *metanephros.* This, according to J. Graham Kerr, holds true not only of the amniotic vertebrates (reptiles, birds, and mammals) but also, with a certain reservation, of the anamniotic vertebrates (fishes and amphibians). "In many of the lower Vertebrates," says this author, "there is no separation between the mesonephros and metanephros, the two forming one continuous structure which acts as the functional kidney. Such a type of renal organ consisting of the series of tubules corresponding to mesonephros together with metanephros may conveniently be termed the opisthonephros." ("Textbook of Embryology," II—Vertebrata, p. 221.) If we accept this view, it is not quite accurate to regard the mesonephros in man as a homologue of the *opisthonephros* of a fish, seeing that the latter is composed not only of mesonephridia (mesonephric tubules), but also of meta-

nephridia (metanephric tubules). A brief description of the three nephridial systems of vertebrate embryos will serve to further clarify their interrelationship.

(1) *The pronephric system:* This consists of a collection of tubules called the pronephros, and a pronephric duct leading to the cloaca, or terminal portion of the alimentary canal. The pronephros is a functional organ in the frog tadpole and other larval amphibia. It is also found in a few teleosts, where it is said to persist as a functional organ in the adult. In other fishes, however, and in all higher forms the pronephros atrophies and becomes reduced to a few rudiments.[2]

(2) *The mesonephric system:* This consists of a collection of nephridial tubules called the mesonephros (Wolffian body). The tubules of the mesonephros do not develop any duct of their own, but utilize the posterior portion of the pronephric duct, the said tubules becoming secondarily connected with this duct in a region posterior to the pronephridia (tubules of the pronephros). The pronephric tubules together with the anterior portion of the pronephric duct then atrophy, while the persisting posterior portion of this duct receives the name of mesonephric or Wolffian duct. The duct in question still terminates in the cloaca, and serves, in the male, the combined function of a urinary and spermatic duct; but, in the female, a special oviduct (the Müllerian duct) is superadded because of the large size of the eggs to be transmitted, the Wolffian or mesonephric duct subserving only the urinary function. The mesonephros is functional in mammalian embryos, but atrophies and disappears coincidently with the development of the permanent kidney. The same is true of amniotic vertebrates generally, except that in the case of reptiles the meso-

[2] The objection may be raised that a purely embryonic organ like the pronephros, which is functional in but few vertebrate adults and which originates in vertebrate embryos only to undergo atrophy, can have no other explanation than that of "recapitulation." The objection, however, fails to take into account the possibility of the organ being serviceable to the *embryo,* in which it may be a provisory solution of the excretory problem and not a vestige of past ancestry.

nephros persists for a few months after hatching in the adult, the definitive kidney of the adult being reinforced during that interval by the still functional mesonephros. In anamniotic vertebrates, however, no separation exists between the mesonephros and the metanephros, the two forming one continuous structure, the opisthonephros, which acts as the functional kidney of the adult.

(3) *The metanephric system:* In the amniotic vertebrates the mesonephros and metanephros are distinct, the former being functional in embryos and in adult reptiles (for a few months after hatching), while the metanephros becomes the definitive kidney of the adult. The metanephros is a collection of nephridial tubules provided with a special urinary duct called the ureter, which empties into the bladder (not the cloaca). The Wolffian or mesonephric duct is retained as a sperm duct in the male (of amniotic vertebrates), but becomes vestigial in the female. Only a certain number of the nephridial tubules of the embryonic metanephros are taken over to form part of the permanent or adult kidney (in mammals, birds, and reptiles).

If, then, as we have previously observed, we follow Kerr in regarding the fish kidney, not as a simple mesonephros, but as an opisthonephros (*i.e.* a combination of mesonephros and metanephros), there is no warrant for interpreting the embryonic mesonephros of man and mammals generally as the fish-kidney stage. But waiving this consideration, and assuming, for the sake of argument, that the fish kidney is a perfect homologue of the human mesonephros, the mere fact of the adoption by the human embryo of a temporary solution of its excretory problem similar to the permanent solution of that problem adopted by the fish, would not, of itself, imply the common ancestry of men and fishes. Such a coincidence would be fully explicable as a case of convergent adaptation occurring in the interest of embryonic economy.

It is, indeed, a well-known fact that larval and embryonic organisms are often obliged to defer temporarily the construc-

tion of the more complex structures of adult life, and to improvise simpler substitutes for use until such a time as they have accumulated a sufficient reserve of energy and materials to complete the work of their more elaborate adult organization. The young starfish, for example, arising as it does from an egg but scantily supplied with yolk, is forced, from the very outset, to shift for itself, in coping with the food-getting problem. Under stress of this necessity, it economizes its slender resources by constructing the extremely simple digestive and motor apparatus characteristic of the larva in its bilaterally-symmetrical *Bipinnaria* stage, and postponing the development of the radially-symmetrical structure characteristic of the adult stage, until it has stored up the wherewithal to complete its metamorphosis.

From this viewpoint, there is no difficulty in understanding why *temporary* solutions of the excretory problem should precede the *definitive* solution of this problem in mammalian embryos. The problem of excretion is urgent from the outset, and its demands increase with the growth of the embryo. It is only natural, then, that a series of improvised structures should be resorted to, in a case of this kind; and, since these temporary solutions of the excretory problem must, of necessity, be as simple as possible, it should not be in the least surprising to find them coinciding with the permanent solutions adopted by inferior organisms less complexly organized than the mammals. Hence the bare fact of resemblance between the transitory embryonic kidney of a mammal and the permanent adult kidney of a fish would have no atavistic significance. We know of innumerable cases in which an identical adaptation occurs in genetically unrelated organisms. The cephalopod mollusc *Nautilus*, for example, solves the problem of light-perception in the identical manner in which it is solved by the vertebrates. This mollusc has the perfect vertebrate type of eye, including the lens and all other parts down to the minutest detail. The fact, however, that the mollusc solves its problem by using the stereotyped solution

found in vertebrates rather than by developing a compound eye analogous to the type found among arthropods, is wholly destitute of genetic significance. In fact, the genetic interpretation is positively rejected by the evolutionists, who interpret the occurrence of similar eyes in molluscs and vertebrates as an instance of "accidental convergence." Even assuming, then, what Kerr denies, namely, a perfect parallelism between the mesonephros of the human embryo and the permanent kidney of an adult fish, the alleged fact that the human embryo temporarily adopts the same type of solution for its excretory problem as the one permanently employed by the fish would not in itself be a proof of our descent from a fish-like ancestor.

In fact, not only is embryological homology of no greater value than adult homology as an argument for evolution, but it is, on the contrary, considerably inferior to the latter, as regards cogency. *Differentiation* pertains to the final or *adult* stage of organisms. Embryonic structures, inasmuch as they are undeveloped and undifferentiated, present for that very reason an appearance of crude and superficial similarity. "Most of what is generally ascribed to the action of the so-called biogenetic law," says T. Garbowski, "is erroneously ascribed to it, since all things that are undeveloped and incomplete must be more or less alike." ("Morphogenetische Studien," Jena, 1903.) When we consider the fact that the metazoa have all a similar unicellular origin, are subject to uniform morphogenetic laws, and are frequently exposed to analogous environmental conditions demanding similar adaptations, it is not at all surprising that they should present many points of resemblance (both in their embryonic and their adult morphology) which are not referable to any particular line of descent. At all events, these resemblances are far too general in their extension to enable us to specify the type of ancestor responsible therefor. More especially is this true of embryological homologies, which are practically valueless as basis for reconstructing the phylogeny of any type. "That certain phenomena," says Oskar Hertwig,

"recur with great regularity and uniformity in the development of different species of animals, is due chiefly to the fact that under all circumstances they supply the necessary condition under which alone the next higher stage in ontogeny (embryological development) can be produced." ("Allgemeine Biologie," 1906, p. 595.) The same author, therefore, proposes to revamp Haeckel's "biogenetisches Grundgesetz" as follows: "We must leave out the words 'recapitulation of forms of extinct ancestors' and substitute for them 'repetition of forms regularly occurring in organic development, and advancing from the simple to the more complex.' " (*Op. cit.*, p. 593.)

Finally, when applied to the problem of man's alleged genetic connection with the ape, the biogenetic principle proves the exact reverse of what the Darwinians desire; for as a matter of fact the young apes resemble man much more closely in the shape of the skull and facial features than do the adult animals. Inasmuch, therefore, as the ape, in its earlier development, reveals a more marked resemblance to man than is present in its later stages, it follows, according to the "biogenetic law," that man is the ancestor of the ape. This, however, is inadmissible, seeing that the ape is by no means a more recent type than man. Consequently, as applied to man, the Haeckelian principle leads to a preposterous conclusion, and thereby manifests its worthlessness as a clue to phylogeny. Julius Kollmann, it is true, gives serious attention to this likeness between young apes and men, and makes it the basis of his scheme of human evolution. "Kollmann," says Dwight, "starts from the fact that the head of a young ape is very much more like that of a child than the head of an old ape is like that of a man. He holds that the likeness of the skull of a very young ape is so great that there must be a family relationship. He believes that some differentiation, some favorable variation, must occur in the body of the mother and so a somewhat higher skull is transmitted to the offspring and is perpetuated. Concerning which Kohlbrugge remarks that 'thus the first men were developed, not from

the adult, but from the embryonic forms of the anthropoids whose more favorable form of skull they managed to preserve in further growth.' . . . Schwalbe makes the telling criticism of these views of Kollmann that much the same thing might be said of the heads of embryonic animals in general that is said of those of apes, and that thus mammals might be said to have come from a more man-like ancestor." (*Op. cit.*, pp. 186, 187.) All of which goes to show that the "biogenetic law" is more misleading than helpful in settling the question of human phylogeny.

§ 3. Rudimentary Organs

Darwin attached great importance to the existence in man of so-called rudimentary organs, which he regarded as convincing evidence of man's descent from the lower forms of animal life. Nineteenth century science, being ignorant of the functional purpose served by many organs, arbitrarily pronounced them to be useless organs, and chose, in consequence, to regard them all as the atrophied and (wholly or partially) functionless remnants of organs that were formerly developed and fully functional in remote ancestors of the race. Darwin borrowed this argument from Lamarck. It may be stated thus: Undeveloped and functionless organs are atrophied organs. But atrophy is the result of disuse. Now disuse presupposes former use. Consequently, rudimentary organs were at one time developed and functioning, viz. in the remote ancestors of the race. Since, therefore, these self-same organs are developed and functional in the lower forms of life, it follows that the higher forms, in which these organs are reduced and functionless, are descended from forms similar to those in which said organs are developed and fully functional.

This argument, however, fairly bristles with assumptions that are not only wholly unwarranted, but utterly at variance with actual facts. In the first place, it wrongly assumes that all reduced organs are functionless, and, conversely, that all

functionless organs are atrophied or reduced. Facts, however, prove the contrary; for we find frequent instances of reduced organs which function, and, *vice versa*, of well-developed organs which are functionless. The tail, for example, in cats, dogs, and certain Catarrhine monkeys, though it discharges neither the prehensile function that makes it useful in the Platyrrhine monkey, nor the protective function that makes it useful to horses and cattle in warding off flies, is, nevertheless, despite its inutility or absence of function, a quite fully developed organ. Conversely, the reduced or undeveloped fin-like wings of the penguin are by no means functionless, since they enable this bird to swim through the water with great facility.

To save his argument from this antagonism of the facts, Darwin resorts to the ingenious expedient of distinguishing between *rudimentary* organs and *nascent* organs. Rudimentary organs are undeveloped organs, which are wholly, or partially, useless. They have had a past, but have no future. Nascent organs, on the contrary, are undeveloped organs, which "are of high service to their possessors" ("Descent of Man," ch. I, p. 28, 2nd ed.). They "are capable of further development" (*ibidem*), and have, therefore, a future before them. He gives the following examples of rudimentary organs: "Rudimentary organs . . . are either quite useless, such as teeth which never cut through the gums, or almost useless, such as the wings of an ostrich, which serve merely as sails." ("Origin of Species," 6th ed., ch. XIV, p. 469.) As an example of a nascent organ, he gives the mammary glands of the oviparous Duckbill: "The mammary glands of the Ornithorhynchus may be considered, in comparison with the udders of a cow, as in a nascent condition." (*Op. cit.*, ch. XIV, p. 470.)

Darwin admits that it is hard to apply this distinction in the concrete: "It is, however, often difficult to distinguish between rudimentary and nascent organs; for we can judge only by analogy whether a part is capable of further development, in which case alone it deserves to be called nascent."

(*Op. cit.*, ch. XIV, p. 469.) For Darwin "judging by analogy" meant judging on the assumption that evolution has really taken place; for he describes rudimentary organs as being "of such slight service that we can hardly suppose that they were developed under the conditions which now exist." ("Descent of Man," ch. I, p. 29.)

He is somewhat perplexed about applying this distinction to the penguin: "The wing of the penguin," he admits, "is of high service, acting as a fin; it may, therefore, represent the nascent state: not that I believe this to be the case; it is more probably a reduced organ, modified for a new function." ("Origin of Species," 6th ed., ch. XIV, pp. 469, 470.) In other words, there is scarcely any objective consideration by which the validity of this distinction can be checked up in practice. Like homology and convergence, like palingenesis and caenogenesis, the distinction between rudimentary and nascent organs is a convenient device, which can be arbitrarily manipulated according to the necessities of a preconceived theory. It is "scientific" sanction for the privilege of blowing hot and cold with the same breath.

The assumption that atrophy and reduction are the inevitable consequence of disuse, or diminution of use, in so far as this decreases the flow of nourishing blood to unexercised parts, is certainly erroneous. Yet Darwin made it the premise of his argument from so-called rudimentary organs. "The term 'disuse' does not relate," he informs us, "merely to lessened action of muscles, but includes a diminished flow of blood to the part or organ, from being subjected to fewer alternations of pressure, or from being in any way less habitually active." ("Origin of Species," 6th ed., p. 469.) As a matter of fact, however, we have many instances in which use has failed to develop and disuse to reduce organs in certain types of animals. As an example in point, we may cite the case of right-handedness among human beings. From time immemorial, the generality of mankind have consistently used the right hand in preference to the left, without any atrophy or

reduction of the left hand, or overdevelopment of the right hand, resulting from this racial practice. "The superiority of one hand," says G. Elliot Smith, "is as old as mankind." (Smithson. Inst. Rpt. for 1912, p. 570.) It is true that only about 6,000 years of human existence are known to history, but, if one accepts the most conservative estimates of glaciologists, man has had a much longer prehistory, the lowest estimates for the age of man being approximately 30,000 years. Thus W. J. Sollas tells us that the Glacial period, in which man first appeared, came to an end about 7,000 years ago, and that the men buried at Chapelle-aux-Saints in France lived about 25,000 years ago. His figures agree with those of C. F. Wright, who bases his calculations on the Niagara Gorge. The Niagara River is one of the postglacial streams, and the time required to cut its gorge has been calculated as 7,000 years. Gerard De Geer, the Swedish scientist, gives 20,000 years ago as the end of glacial and the commencement of recent or postglacial time. He bases his estimates on the sediments of the Yoldia Sea in Sweden. His method consists in the actual counting of certain seasonally-laminated clay layers, presumably left behind by the receding ice sheet of the continental glacier. The melting is registered by annual deposition, in which the thinner layers of finer sand from the winter flows alternate with thicker layers of coarser material from the summer flows. In warm years, the layers are thicker, in colder years they are thinner, so that these laminated Pleistocene clays constitute a thermographic as well as a chronological record. De Geer began his study of Pleistocene clays in 1878, and in 1920 he led an expedition to the United States, for the purpose of extending his researches. (Cf. *Science*, Sept. 24, 1920, pp. 284-286.) At that time, he claimed to have worked out the chronology of the past 12,000 years. His figure of 20,000 years for postglacial time, while very displeasing to that reckless foe of scientific caution and conservatism, Henry Fairfield Osborn, tallies very well with the estimates of Sollas and Wright. H. Obermaier, basing his computation

on Croll's theory that glaciation is caused by variations in the eccentricity of the earth's orbit about the sun, which would bring about protracted winters in the hemisphere having winter, when the earth was farthest from the sun (with consequent accumulation of ice), gives 30,000 years ago as the date of the first appearance of man on earth. Father Hugues Obermaier, it may be noted, like Abbé Henri Breuil, is one of the foremost authorities on the subject of prehistoric Man. Both are Catholic priests.

All such computations of the age of man are, of course, uncertain and theoretical. Evolutionists calculate it in hundreds of thousands, and even millions, of years. After giving such a table of recklessly tremendous figures, Osborn has the hypocritical meticulosity to add that, for the sake of *precision* (save the mark!) the nineteen hundred and some odd years of the Christian era should be added to his figures. But, even according to the most conservative scientific estimates, as we have seen, man is said to have been in existence for 30,000 years, and the prevalence of right-handedness among men is as old as the human race. One would expect, then, to find modern man equipped with a gigantic right arm and a dwarfed left arm. In other words, man should exhibit a condition comparable to that of a lobster, which has one large and one small chela. Yet, in spite of the fact that the comparative inaction of the human left hand is supposed to have endured throughout a period of, at least, 30,000 years, this state of affairs has not resulted in the faintest trace of atrophy or retrogression. Bones, muscles, tendons, ligaments, nerves, blood vessels, and all parts are of equal size in both arms and both hands. Excessive exercise may overdevelop the musculature of the right arm, but this is an individual and acquired adaptation, which is never transmitted to the offspring, *e.g.* the child of a blacksmith does not inherit the muscular hypertrophy of his father. Disuse, therefore, has not the efficacy which Lamarck and Darwin ascribed to it.

In fine, it must be recognized, once for all, that organisms are not molded on a Lamarckian basis of use, nor yet on a Darwinian basis of selected utility. Expediency, in other words, is not the sole governing principle of the organic world. Neither instinctive habitude nor the struggle for existence succeeds in forcing structural adaptation of a predictable nature. Animals with different organic structure have the same instincts, *e.g.* monkeys with, and without, prehensile tails alike dwell in trees; while animals having the same organic structure may have different instincts, *e.g.* the rabbit, which burrows, and the hare, which does not, are practically identical in anatomical structure. Again, some animals are highly specialized for a function, which other animals perform without specialized organs, as is instanced in the case of moles, which possess a special burrowing apparatus, and prairie-dogs, which burrow without a specialized apparatus. Any system of evolution, which ignores the internal or hereditary factors of organic life and strives to explain all in terms of the environmental factors, encounters an insuperable obstacle in this remorseless resistance of conflicting facts.

Another flaw in the Darwinian argument from rudimentary organs is that it confounds, in many cases, *apparent,* with *real* inutility (or absence of function). Darwin and his followers frequently argued out of their ignorance, and falsely concluded that an organ was destitute of a function, merely because *they* had failed to discover its utility. Large numbers, accordingly, of highly serviceable organs were catalogued as vestigial or rudimentary, simply because nineteenth century science did not comprehend their indubitable utility. With the advance of present-day physiology, this list of "useless organs" is being rapidly depleted, so that the scientific days of the rudimentary organ appear to be numbered. At any rate, in arbitrarily pronouncing many important and functioning organs to be useless vestiges of a former stage in the history of the race, the Darwinians were not the friends of Science, but rather its reactionary enemies, inasmuch as they sought to discourage

further investigation by their dogmatic decision that there was no function to be found. In so doing, however, they were merely exploiting the ignorance of their times in the interest of a preconceived theory, which whetted their appetite for discovering, at all costs, the presence in man of functionless organs.

Their anxiety in this direction led them to consider the whole group of organs constituting a most important regulatory and coördinative system in man and other vertebrates as so many useless vestigial organs. This system is called the *cryptorhetic system* and is made of internally-secreting, ductless glands, now called *endocrine glands*. These glands generate and instill into the blood stream certain chemical substances called *hormones*, which, diffusing in the blood, produce immediate stimulatory, and remote metabolic effects on special organs distant from the endocrine gland, in which the particular hormone is elaborated. As examples of such endocrine glands, we may mention the pineal gland (epiphysis), the pituitary body (hypophysis), the thyroid glands, the parathyroids, the islelets of Langerhans, the adrenal bodies (suprarenal capsules), and the interstitial cells of the gonads. The importance of these alleged useless organs is now known to be paramount. Death, for instance, will immediately ensue in man and other animals, upon extirpation of the adrenal bodies.

The late Robert Wiedersheim, it will be remembered, declared the pineal gland or epiphysis to be the surviving vestige of a "third eye" inherited from a former ancestor, in whom it opened between the parietal bones of the skull, like the median or *pineal eye* of certain lizards, the socket of which is the parietal foramen formed in the interparietal suture. If the argument is based on homology alone, then the coincidence in position between the human epiphysis and the median optic nerve of the lizards in question has the ordinary force of the evolutionary argument from homology. But when one attempts to reduce the epiphysis to the status of a useless ves-

tigial rudiment, he is in open conflict with facts; for the pineal body is, in reality, an endocrine gland generating and dispersing a hormone, which is very important for the regulation of growth in general and of sexual development in particular. Hence this tiny organ in the diencephalic roof, no larger than a grain of wheat, is not a functionless rudiment, but an important functioning organ of the cryptorhetic system. We have no ground, therefore, on this score for inferring that our pineal gland functioned in former ancestors as a median eye comparable to that of the cyclops Polyphemus of Homeric fame.

In like manner, the pituitary body or hypophysis, which in man is a small organ about the size of a cherry, situated at the base of the brain, buried in the floor of the skull, and lying just behind the optic chiasma, was formerly rated as a rudimentary organ. It was, in fact, regarded as the vestigial remnant of a former connection between the neural and alimentary canals, reminiscent of the invertebrate stage. "The phylogenetic explanation of this organ generally accepted," says Albert P. Mathews, "is that formerly the neural canal connected at this point with the alimentary canal. A probable and almost the only explanation of this, though an explanation almost universally rejected by zoölogists, is that of Gaskell, who has maintained that the vertebrate alimentary canal is a new structure, and that the old invertebrate canal is the present neural canal. The infundibulum, on this view, would correspond to the old invertebrate œsophagus, the ventricle of the thalamus to the invertebrate stomach, and the canal originally connected posteriorly with the anus. The anterior lobe of the pituitary body could then correspond to some glandular adjunct of the invertebrate canal, and the nervous part to a portion of the original circumœsophageal nervous ring of the invertebrates." ("Physiological Chemistry," 2nd ed., 1916, pp. 641, 642.)

This elaborate piece of evolutionary contortion calls for no comment here. We are only interested in the fact that this

wild and weird speculation was originally inspired by the false assumption that the hypophysis was a functionless organ. As a matter of fact, it is the source of two important hormones. The one generated in its anterior lobe is *tethelin,* a metabolic hormone, which promotes the growth of the body in general and of the bony tissue in particular. Hypertrophy and overfunction of this gland produces giantism, or acromegaly (enlargement of hands, feet, and skull), while atrophy and underfunction of the anterior lobe results in infantilism, acromikria (diminution of extremities, *i.e.* hands, feet, head), obesity, and genital dystrophy (*i.e.* suppression of secondary sexual characters). The posterior lobe of the pituitary body constitutes, with the *pars intermedia,* a second endocrine gland, which generates a stimulatory hormone called *pituitrin.* This hormone stimulates unstriated muscle to contract, and thereby regulates the discharge of secretions from various glands of the body, *e.g.* the mammary glands, bladder, etc. Hence the hypophysis, far from being a useless organ, is an indispensable one. Moreover, it is an integral and important part of the cryptorhetic system.

The same story may be repeated of the thyroid glands. These consist of two lobes located on either side of the windpipe, just below the larynx (Adam's apple), and joined together across the windpipe by a narrow band or isthmus of their own substance. Gaskell homologized them with a gland in scorpions, and Mathew says that, if his surmise is correct, "the thyroid represents an accessory sexual organ of the invertebrate." (*Op. cit.,* p. 654.) They are, however, endocrine glands, that generate a hormone known as *thyroxin,* which regulates the body-temperature, growth of the body in general, and of the nervous system in particular, etc., etc. Atrophy or extirpation of these glands causes cretinism in the young and myxoedema in adults. Without a sufficient supply of this hormone, the normal exercise of mental powers in human beings is impossible. The organ, therefore, is far from being a useless vestige of what was formerly useful.

George Howard Parker, the Zoölogist of Harvard, sums up the case against the Darwinian interpretation of the endocrine glands as follows: "The extent to which hormones control the body is only just beginning to be appreciated. For a long time anatomists have recognized in the higher animals, including man, a number of so-called ductless glands, such as the thyroid gland, the pineal gland, the hypophysis, the adrenal bodies, and so forth. These have often been passed over as unimportant functionless organs whose presence was to be explained as an inheritance from some remote ancestor. But such a conception is far from correct. If the thyroids are removed from a dog, death follows in from one to four weeks. If the adrenal bodies are excised, the animal dies in from two to three days. Such results show beyond doubt that at least some of these organs are of vital importance, and more recent studies have demonstrated that most of them produce substances which have all the properties of hormones." ("Biology and Social Problems," 1914, pp. 43, 44.)

Even the *vermiform appendix* of the cæcum, which since Darwin's time has served as a classic example of a rudimentary organ in man, is, in reality, not a functionless organ. Darwin, however, was of opinion that it was not only useless, but positively harmful. "With respect to the alimentary canal," he says, "I have met with an account of only a single rudiment, namely, the vermiform appendage of the cæcum. . . . Not only is it useless, but it is sometimes the cause of death, of which fact I have lately heard two instances. This is due to small hard bodies, such as seeds, entering the passage and causing inflammation." ("Descent of Man," 2nd ed., ch. I, pp. 39, 40.) The idea that seeds cause appendicitis is, of course, an exploded superstition, the hard bodies sometimes found in the appendix being fecal concretions and not seeds—"The old idea," says Dr. John B. Deaver, "that foreign bodies, such as grape seeds, are the cause of the disease, has been disproved." (Encycl. Americana, vol. 2, p. 76.) What is more germane to the point at issue, however, is that Dar-

win erred in denying the utility of the vermiform appendix. For, although this organ does not discharge in man the important function which its homologue discharges in grain-eating birds and also in herbivorous mammals, it subserves the secondary function of lubricating the intestines by means of a secretion from its muciparous glands.

Darwin gives the *semilunar fold* as another instance of a vestigial organ, claiming that it is a persistent rudiment of a former third eyelid or *membrana nictitans,* such as we find in birds. "The nictitating membrane, or third eyelid," he says, "with its accessory muscles and other structures, is especially well developed in birds, and is of much functional importance to them, as it can be rapidly drawn across the whole eyeball. It is found in some reptiles and amphibians, and in certain fishes as in sharks. It is fairly well developed in the two lower divisions of the mammalian series, namely, in the monotremata and marsupials, and in some higher mammals, as in the walrus. But in man, the quadrumana, and most other mammals, it exists, as is admitted by all anatomists, as a mere rudiment, called the semilunar fold." (*Op. cit.,* ch. I, pp. 35, 36.) Here Darwin is certainly wrong about his facts; for the so-called third eyelid is not well developed in the two lower divisions of the mammalian series (*i.e.* the monotremes and the marsupials) nor in any other mammalian type. "With but few exceptions," says Remy Perrier, "the third eyelid is not so complete as among the birds; (in the mammals) it never covers the entire eye. For the rest, it is not really perceptible except in certain types, like the dog, the ruminants, and, still more so, the horse. In the rest (of the mammals) it is less developed." ("Elements d'anatomie comparée," Paris, 1893, p. 1137.) Moreover, Darwin's suggestion leaves us at sea as to the ancestor, from whom our "rudimentary third eyelid" has been inherited. His mention of birds as having a well developed third eyelid is not very helpful, because all evolutionists agree in excluding the birds from our line of descent. The reptiles are more promising

candidates for the position of ancestors, but, as no trace of a third eyelid could possibly be left behind in the imperfect record of the fossiliferous rocks (soft parts like this having but slight chance of preservation), we do not really *know* whether the palæozoic reptiles possessed this particular feature, or not. Nor can we argue from analogy and induction, because not *all* modern reptiles are equipped with third eyelids. Hence the particular group of palæozoic reptiles, which are supposed to have been our progenitors, may not have possessed any third eyelid to bequeath to us in the reduced and rudimentary form of the plica semilunaris. If it be replied, that they *must* have had this feature, because otherwise we would have no ancestor from whom we could inherit our semilunar fold, it is obvious that such argumentation assumes the very point which it ought to prove, namely: the actuality of evolution. Rudiments are supposed to be a proof for evolution, and not, *vice versa,* evolution a proof for rudiments.

Finally, the basic assumption of Darwin that the semilunar fold is destitute of function is incorrect; for this crescent-shaped fold situated in the inner or nasal corner of the eye of man and other mammals serves to regulate the flow of the lubricating lacrimal fluid (which we call tears). True this function is secondary compared with the more important function discharged by the nictitating membrane in birds. In the latter, the third eyelid is a pearly-white (sometimes transparent) membrane placed internal to the real eyelids, on the inner side of the eye, over whose surface it can be drawn like a curtain to shield the organ from excessive light, or irritating dust; nevertheless, the regulation of the flow of lacrimal humor is a real function, and it is therefore entirely false to speak of the semilunar fold as a functionless rudiment.

The *coccyx* is likewise cited by Darwin as an example of an inherited rudiment in man. "In man," he says, "the os coccyx, together with certain other vertebræ hereafter to be described, though functionless as a tail, plainly represents this part in other vertebrate animals." (*Op. cit.,* ch. I, p. 42.)

That it serves no purpose *as a tail,* may be readily admitted, but that it serves no purpose *whatever,* is quite another matter. As a matter of fact, it serves for the attachment of several small muscles, whose functioning would be impossible in the absence of this bone. Darwin himself concedes this; for he confesses that the four vertebræ of the coccyx "are furnished with some small muscles." (*Ibidem.*) We may, therefore, admit the homology between the human coccyx and the tails of other vertebrates, without being forced to regard the latter as a useless vestigial organ. It may be objected that the attachment of these muscles might have been provided for in a manner more in harmony with our ideas of symmetry. To this we reply that Helmholtz criticized the human eye for similar reasons, when he said that he would remand to his workshop for correction an optical instrument so flawed with defects as the human eye. But, after all, it was by the use of these selfsame imperfect eyes that Helmholtz was enabled to detect the flaws of which he complained. When man shall have fully fathomed the difficulties and obstructions with which organic morphogeny has to contend in performing its wonderful work, and shall have arrived at an elementary knowledge of the general laws of morphogenetic mechanics, he will be more inclined to admire than to criticize. It is a mistake to imagine that the finite works of the Creator must be perfect from *every* viewpoint. It suffices that they are perfect with respect to the particular *purpose* which they serve, and this purpose must not be narrowly estimated from the standpoint of the created work itself, but from that of its position in the universal scheme of creation. All such partial views as the Helmholtzian one are false views.

Another consideration which Darwin and his partisans have failed to take into account is the possibility of an *ontogenetic,* as well as a phylogenetic, explanation of rudimentary organs. That is to say, rudimentary organs might, so far as *a priori* reasons are concerned, be the now useless vestiges of organs

formerly developed and functional *in the fœtus,* and need not necessarily be interpreted as traces of organs that functioned formerly in remote racial ancestors. That there should be such things as special fœtal organs, which atrophy in later adult life, is a possibility that ought not to excite surprise. During its uterine existence, the fœtus is subject to peculiar conditions of life, very different from those which prevail in the case of adult organisms—*e.g.* respiration and the digestive process are suspended, and there is a totally different kind of circulation. What, then, more natural than that the fœtus should require special organs to adapt it to these special conditions of uterine life? Such organs, while useful and functional in the earlier stages of embryonic development, will, so soon as birth and maturity introduce new conditions of life, become superfluous, and therefore doomed, in the interest of organic economy, to ultimate atrophy and degeneration, until nothing is left of them but vestigial remnants.

The thymus may be cited as a probable instance of such an organ. This organ, which is located in front of the heart and behind the breastbone, in the region between the two lungs, consists, at the period of its greatest development in man, of a two-lobed structure, 5 cm. long and 4 cm. wide, with a thickness of 6 mm. and a maximum weight of 35 grams. It is supplied with numerous lymphoid cells, which are aggregated to form lymphoid follicles (*cf.* Gray's "Anatomy," 20th ed., 1918, pp. 1273, 1274; Burton-Opitz' "Physiology," 1920, p. 964). This organ is a transitory one, well developed at birth, but degenerating, according to some authors, after the second year of life (*cf.* Starling's "Physiology," 3rd ed., 1920, p. 1245); according to others, however, not until the period of full maturity, namely, puberty. (*Cf.* Gray's "Anatomy," *loc. cit.*) W. H. Howell cites both opinions, without venturing to decide the matter (*cf.* his "Physiology," 8th ed., 1921, pp. 869, 870). It was at one time classified as a rudimentary or functionless organ. Later on, however, it was thought by certain observers to be an endocrine gland, yielding a secretion important for

the growth of young mammals. This took it out of the class of useless vestigial organs, but the recent discovery that it is indispensable to birds as furnishing a secretion necessary for the formation of the tertiary envelopes (egg membrane and shell) of their eggs, has tended to revive the idea of its being a vestigial organ inherited from the lower vertebrates.

Thus Dr. Oscar Riddle, while admitting that the thymus gland in man has some influence on the growth of the bones, contends that the newly-discovered function of this gland in birds is much more important, since without it none of the vertebrates, excepting mammals, could reproduce their young. "It thus becomes clear," he says, "that though the thymus is almost without use in the human being, it is in fact a sort of 'mother of the race.' The higher animals could not have come into existence without it. For even while our ancestors lived in the water, it was the thymus of these ancestors which made possible the production of the egg-envelopes within which the young were cradled and protected until they were ready for an independent life." (*Science*, Dec. 28, 1923, Suppl. XIII, XIV.)

This conclusion, however, is far too hasty. For, even if we disregard as negligible the minor function, that Riddle assigns to the thymus in man, there remains another possibility, which H. H. Wilder takes into account, namely, that the thymus may, in certain cases, be a temporary substitute for the lymphatic vessels. Having called attention to certain determinate channels found in some of the lower vertebrates, he tells us that these "can well be utilized as adjuncts of the lymphatic system until their function can be supplied by definite lymphatic vessels." He then resumes his discussion of the lymph nodules in mammals as follows: "Aside from the solitary and aggregated nodules, both of which appear to be centers of origin of lymphocytes, there are numerous other places in which the cellular constituents of the blood are developed. Many of these, as in the case of the aggregated nodules of the intestines, are developed within the wall of the

alimentary canal and are therefore endodermic in origin. These include the tonsils, the *thymus,* and thyroid glands, the associated epithelial bodies, and, perhaps, the spleen. . . . In their function as formative nidi for the cellular elements of the blood these organs form physiologically important auxiliaries to the vascular system as a whole, but belong elsewhere in their anatomical developmental affinities." ("History of the Human Body," 2nd ed., 1923, p. 395—italics mine.)

This being the case, it is much more reasonable to interpret the thymus as an ontogenetic (embryonic), rather than a phylogenetic (racial) rudiment. It has been observed that, in the case of reptiles which lack definite lymphatic glands (which function in man as formative centers of lymphocytes or white blood corpuscles), the thymus is extraordinarily developed and abounds in lymphoid cells. It has also been observed that the formation of lymphocytes in the lymphatic glands is regulated by the digestive process; for, after digestion, the activity of these glands increases and the formation of leucocytes is accelerated. Since, then, the lymphatic glands appear to require the stimulus of the digestive process to incite them to action, it is clear that in the fœtus, which lacks the digestive process, the lymphatic glands will not be stimulated to action, and that the task of furnishing lymphocytes will devolve upon the thymus. After birth, the digestive process commences and the lymphatic glands become active in response to this stimulus. As the function of forming lymphocytes is transferred from the thymus to the lymphatic glands, the former is gradually deprived of its importance, and, in the interest of organic economy, it begins to atrophy, until, at the end of the child's second year, or, at latest, when the child has reached sexual maturity, nothing but a reduced vestige remains of this once functional organ. "The thymus," says Starling, "forms two large masses in the anterior mediastinum which in man grow up to the second year of life and then rapidly diminish, so that only traces are to be found at puberty. It contains a large amount of lymphatic tissue and

is therefore often associated with the lymphatic glands as the seat of the formation of lymph corpuscles. . . . In certain cases of arrested development or of general weakness in young people, the thymus has been found to be persistent." ("Physiology," 3rd ed., 1920, p. 1245.)

In the light of these facts, it is utterly unreasonable to regard the thymus as a practically useless rudiment inherited from the lower vertebrates. "That they have an important function in the young animal," says Albert Mathews, "can hardly be doubted." ("Physiological Chemistry," 1916, p. 675.) In fact, the peculiar nature of their development in the young and their atrophy in the adult forces such a conclusion upon us. The thymus, therefore, is, in all probability, an ontogenetic, and not a phylogenetic, rudiment. It might conceivably be exploited as a biogenetic recapitulation of a reptilian stage in man, just as the so-called fish-kidney of the human embryo is exploited for evolutionary interpretation. The principles by which such a view may be refuted have been given previously. But, in any case, it is folly to interpret the thymus as a rudiment in the racial, rather than embryonic sense. Moreover, the possibility of an ontogenetic interpretation of rudiments must not be restricted to the thymus, but must be accepted as a general and legitimate alternative for the phylogenetic interpretation.

In the last place, it remains for us to consider the Darwinian argument, based upon so-called rudimentary organs, from the standpoint of the science of genetics. Darwin, as we have remarked elsewhere, was ignorant of the non-inheritability of those inconstant individual variations now known as fluctuations. He was somewhat perplexed, when Professor L. Meyer pointed out the extreme variability in position of the "projecting point" on the margin of the human ear, but he still clung to his original contention that this "blunt point" was a surviving vestige of the apex of the pointed ears found in donkeys and horses, etc. "Nevertheless," he says, "in some cases my original view, that the points are vestiges of the tips

of formerly erect and pointed ears, still seems to be probable." ("Descent of Man," 2nd ed., ch. I, p. 34.) Darwin, as Ranke points out, was mistaken in homologizing his famous "tubercule" with the apex of bestial ears. "The acute extremity of the pointed animal ear," says this author, "does not correspond to this prominence designated by Darwin, but to the vertex of the helix." ("Der Mensch," II, p. 39.) The feature in question is, moreover, a mere fluctuation due to the degree of development attained by the cartilage: hence its variability in different human beings. In very extreme cases, fluctuations of this sort, may be important enough to constitute an *anomaly*, and, as anomalies are often interpreted as atavisms and reversions to a primitive type, it may be well to advert to this subject here.

Dwight has an excellent chapter on anatomical variations and anomalies. (*Cf.* "Thoughts of a Catholic Anatomist," 1911, ch. IX.) He tells us that "a thigh bone a little more bent, an ear a little more pointed, a nose a little more projecting . . . a little more or a little less of anything you please—this is variation." "An anatomical anomaly," he says, "is some peculiarity of any part of the body which cannot be expressed in terms of more or less, but is distinctly new." He divides the latter into two classes, namely: those which consist in the repetition of one or more elements in a series, *e.g.* the occurrence of supernumerary legs in an insect, and those which consist in the suppression of one or more elements in a series, *e.g.* the occurrence of eleven pairs of ribs in a man. Variations and anomalies are fluctuational or mutational, according as they are based on changes in the soma alone, or on changes in the germ plasm. Variations, however, are more likely to be non-inheritable fluctuations, and anomalies to be inheritable mutations. We shall speak of the latter presently. In the meantime we may note that the main trouble with interpreting these anatomical irregularities as "reversive" or "atavistic" is that they would connect man with all sorts of quite impossible lines of descent. "In my early days of anatomy,"

says Dwight, "I thought that I must be very ignorant, because I could not understand how the occasional appearance in man of a peculiarity of some animal outside of any conceivable line of descent could be called a reversion, as it soon became the custom to call it. . . . It was only later that I grasped the fact that the reason I could not understand these things was that there was nothing to understand. It was sham science from beginning to end." (*Op. cit.*, p. 209.) By way of anomaly, almost any human peculiarity can occur in animals, and, conversely, any bestial peculiarity in man, but the resemblance to man of an animal outside of the alleged line of human descent represents a grave difficulty for the theory of evolution, and not an argument in its favor.

The human body is certainly not a *mosaic of heterogenetic organs, i.e.* a complex of structures inherited from any and every sort of animal, whether extant or extinct; for such a vast number and variety of ancestors could not possibly have coöperated to produce man. Prof. D. Carazzi, in his Address of Inauguration in the Chair of Zoölogy and Comparative Anatomy at the University of Padua, Jan. 20, 1906, excoriated with scathing irony the sham Darwinian science, of which Dwight complains. "But even in the serious works of pure science," says the Italian zoölogist, "we read, for example, that the over-development of the postauricular muscles sometimes observed in man is an atavistic reminiscence of the muscles of the helix of the ear of the horse and the ass. And so far so good, because it gives evidence of great modesty in recognizing as our ancestors those well-deserving and long-eared quadrupeds. But this is not all; there appear at times in a woman one or more anomalous mammary glands below the pectoral ones; and here, too, they insist on explaining the anomaly as a reversion to type, that is, as an atavistic reminiscence of the numerous mammary glands possessed by different lower mammals; the bitch, for example. . . .

"But the supernumerary mammary glands are not a rever-

sion to type; anomalous mammary glands may appear upon the median line, upon the deltoid, and even upon the knee, regions far-distant from the 'milk-line.' So with regard to the postauricular muscles we must say that according to the laws of Darwinism the cases of anomalous development are not interpretable as reversions to type. All these features are not phylogenetic reminiscences, but anomalies of development, of such a nature that, if we should wish to make use of them for establishing the line of human descent, we would have to say that man descends from the swine, from the solipeds and even from the cetaceans, returning, namely, to the old conception of lineal descent, that is, to Buffon's idea of the concatenation of creatures." ("Teorie e critiche nella moderna biologia," 1906.)

Darwin's doctrine, however, on the origin and significance of rudimentary organs has been damaged by genetic analysis in a yet more serious fashion. In fact, with the discovery that anomalous *suppression* and anomalous *duplication* of organs may result from *factorial mutation,* this Darwinian conception received what is tantamount to its deathblow. Darwin, it will be remembered, was convinced that the regression of organs was brought about by "increased disuse controlled by natural selection." (Cf. "Origin of Species," 6th ed., ch. V.) Such phenomena, he thought, as the suppression of wings in the Apteryx and the reduction of wings in running birds, arose from their "inhabiting ocean islands," where they "have not been exposed to the attacks of beasts, and consequently lost the power of using their wings for flight." ("Descent of Man," 6th ed., ch. I, p. 32.) In some cases, he believed that disuse and natural selection had coöperated *ex aequo* to produce results of this nature, *e.g.* the reduction of the eyes in the mole and in Ctenomys; for this reduction, he claims, has some selection-value, inasmuch as reduction of the eyes, adhesion of the lids, and covering with hair tends to protect the unused and useless eye against inflammation. In other cases, however, he is inclined to discount the idea that suppression of organs

is an "effect of long-continued disuse," and to regard the phenomenon as "wholly, or mainly, due to natural selection," *e.g.* in the case of the wingless beetles of the island of Madeira. "For during successive generations," he reasons, "each individual beetle which flew least, either from its wings having been ever so little less developed or from indolent habit, will have had the best chance of surviving from not being blown out to sea; and, on the other hand, those beetles which most readily took to flight would oftenest have been blown to sea, and thus destroyed." In a third class of instances, however, he assigns the principal rôle to disuse, *e.g.* in the case of the blind animals "which inhabit the caves of Carniola and Kentucky, because," as he tells us, "it is difficult to imagine that eyes, though useless, could be injurious to animals living in darkness." Hence he concludes that, as the obliteration of eyes has no selection-value, under the circumstances prevailing in dark caves, "their loss may be attributed to disuse." (Cf. "Origin of Species," 6th ed., ch. V, pp. 128-133.)

Morgan's comment on these elaborate speculations of Darwin is very caustic and concise. Referring to factorial mutations, which give rise to races of flies having *supernumerary* and *vestigial* organs, he says: "In contrast to the last case, where a character is doubled, is the next one in which the eyes are lost. This change took place at a single step. All the flies of this stock, however, cannot be said to be eyeless, since many of them show pieces of eye—indeed the variation is so wide that the eye may even appear like a normal eye unless carefully examined. Formerly we were taught that eyeless animals arose in caves. This case shows that they may also arise suddenly in glass milk bottles, by a change in a single factor.

"I may recall in this connection that wingless flies also arose in our cultures by a single mutation. We used to be told that wingless insects occurred on desert islands because those insects that had the best developed wings were blown out to sea.

Whether this is true or not, I will not pretend to say, but at any rate wingless insects may also arise, not through a slow process of elimination, but at a single step." ("A Critique of the Theory of Evolution," 1916, pp. 66, 67.)

In directing attention to the fact that a permanent and inheritable reduction of organs to the vestigial state can result from mutation, we do not, of course, intend to exclude the possible occurrence of somatic atrophy due to lack of exercise rather than to germinal change. Thus the blind species of animals in caves may, in some instances, be persistently blind, because of the persistent darkness of the environment in which they live, and not by reason of any inherited factor for blindness. Darwin gives one such instance, namely, that of the cave rat *Neotoma*. To test such cases, the blind animals would have to be bred in an illuminated environment. If, under this condition, they failed to develop normal eyes, the blindness would be due to a germinal factor, and would be inherited in an illumined. no less than a dark, environment.

In any case, a mutation which suppresses a character is not, as we have seen, a specific change, but merely one of the varietal order, which does not result in the production of a genuine new species. The factorial mutant with a vestigial wing or eye belongs to the same species as its wild or normal parent stock. Moreover, neither disuse nor natural selection has the slightest power to induce mutations of this kind. If mutation be the cause of the blindness of cave animals, then their presence in such caves must be accounted for by supposing that they migrated thither because they found in the cave a most suitable environment for safety, foraging, etc. Darkness alone, however, could never induce germinal, but, at most, merely somatic blindness. The Lamarckian factor of disuse and the Darwinian factor of selection have been definitely discredited as agents which could bring about hereditarily-transmissible modifications.

§ 4. Fossil Links

All efforts, then, to establish, by means of anatomical and embryological homologies, the lineal descent of man from any known type of monkey or ape have ended in ignominious failure. Comparative anatomy and embryology can, at most, only furnish grounds for extremely vague and indefinite speculations regarding the descent of man, but they can never become a basis for specific conclusions with respect to the phylogeny of *Homo sapiens*. Every known form of ape, whether extant or extinct, is, as we have seen, far too specialized in its adaptation to arboreal life to pass muster as a feasible ancestor. The only conceivable manner in which the human body could be related to simian stock is by way of collateral descent, and the only means of proving such descent is to adduce a series of intermediate fossil types connecting modern men and modern apes with this alleged common ancestor of both. "The ascent (*sic*) of man as one of the Primates," says Henry Fairfield Osborn, "was parallel with that of the families of apes. Man has a long line of ancestry of his own, perhaps two million or more years in length. He is not descended from any known form of ape either living or fossil." (*The Ill. London News*, Jan. 8, 1921, p. 40.)

This theory of a hypothetical primate ancestor of man, which is supposed to have inhabited the earth during the earlier part of the Tertiary period, and to have presented a more man-like appearance than any known type of ape, was first propounded by Karl Snell in 1863. It was popularized at the beginning of the present century by Klaatsch, who saw in it a means of escape from the absurdities and perplexities of the theory of lineal descent—"the less," says the latter, "an ape has changed from its original form, just so much the more human it appears." This saying is revamped by Kohlbrugge to read: "Man comes from an original form much more like himself than any existing ape." Kohlbrugge's comment is as follows: "The line of descent of man thus receives

on the side of the primates a quite different form from its previous one. Such new hypotheses as those of Hubrecht and Klaatsch seem, therefore, fortunate for nature-philosophers, because evolution always failed us when we compared known forms in their details, and led us only to confusion. But if one works with such distant hypothetical ancestors, one escapes much disillusioning." (Quoted by Dwight, *op. cit.*, p. 195.)

One thing, at any rate, is certain, namely: that we do not possess any fossils of this primitive "large brained, erectly walking primate," who is alleged to have roamed the earth during the eocene or oligocene epoch. The Foxhall Man, whose culture Osborn ascribes to the Upper Pliocene, is far too recent, and, what is worse, far too intelligent, to be this Tertiary Ancestor. The *Pithecanthropus erectus*, likewise, is excluded for reasons which we shall presently consider. Meanwhile, let it be noted, that we have Osborn's assurance for the fact that we are descended from a brainy and upright oligocene ancestor, as yet, however, undiscovered.

But the situation is more hopeful, if we hark back to a still more remote period, whose remains are so scarce and fragmentary, as to eliminate the possibility of embarrassment arising from intractable details. "Back of this," says Osborn, ". . . was a prehuman arboreal stage." (*Loc. cit.*) Here, then, we are back again in the same old rut of tree-climbing simian ancestry, whence we thought to have escaped by abandoning the theory of lineal descent; and, before we have time to speculate upon how we got there, Prof. Wm. Gregory of the American Museum is summoned by Osborn to present us with specimens of this prehuman arboreal stage. This expert, it would seem, favored up till the year 1923 the fossil jaw of the *Propliopithecus* as representing the common root, whence the human race diverged, on one side, and the races of anthropoid apes, on the other. (Cf. Osborn's *Museum-leaflet* of 1923 on "The Hall of the Age of Man," p. 29.) On April 14, 1923, however, Gregory announced the deposition of *Proplio-*

pithecus and the enthronement of the jaw of *Dryopithecus*. This sudden accession of *Dryopithecus* to the post of common ancestor of apes and men was due to the discovery by Dr. Barnum Brown of three fossil jaws of *Dryopithecus* in the Miocene deposits of the Siwalik beds in northern India. By some rapturous coincidence, the three jaws in question happen to come from three successive "horizons," and to be representative of just three different stages in the evolution of *Dryopithecus*. Doctor Gregory finds, moreover, that the patterns of the minute cracks and furrows on the surviving molar teeth correspond to those on the surface of the enamels of modern ape and human teeth. Hence, with that ephemeral infallibility, which is characteristic of authorities like Doctor Gregory, and which is proof against all discouragement by reason of past blunders, the one who told us but a year ago that the cusps of all the teeth of *Propliopithecus* "are exactly such as would be expected in the common starting point for the divergent lines leading to the gibbons, to the higher apes, and to man" (*loc. cit.*), now tells us that both we and the apes have inherited our teeth from *Dryopithecus,* who had heretofore remained neglected on the side-lines. In 1923, apparently, Dr. Gregory was unimpressed with the crown patterns of *Dryopithecus,* whose jaw he then excluded from the direct human line. (Cf. *Museum-leaflet,* p. 5.) Now, however, that the new discoveries have brought *Dryopithecus* into the limelight, and, particularly because these jaws were found in *Miocene* deposits, Gregory has shifted his favor from *Propliopithecus* to *Dryopithecus*. (Cf. *Science,* April 25, 1924, suppl. XIII.)

When palæontologists are obliged to do a *volte face* of this sort, one ought not to scoff. One ought to be an optimist, and eschew above all the spirit of the English statesman, who, on hearing a learned lecture by Pearson on the question of whether Man was descended from hylobatic, or troglodytic stock, was guilty of the following piece of impatience: "I am not particularly interested in the descent of man . . .

this scientific pursuit of the dead bones of the past does not seem to me a very useful way of spending life. I am accustomed to this mode of study; learned volumes have been written in Sanscrit to explain the conjunction of the two vowels 'a' and 'u.' It is very learned, very ingenious, but not very helpful. . . . I am not concerned with my genealogy so much as with my future. Our intellects can be more advantageously employed than in finding our diversity from the ape. . . . There may be no spirit, no soul; there is no proof of their existence. If that is so, let us do away with shams and live like animals. If, on the other hand, there is a soul to be looked after, let us all strain our nerves to the task; there is no use in digging into the sands of time for the skeletons of the past; build your man for the future." (Smithson. Inst. Rpt. for 1921, pp. 432, 433.) It is to be hoped, however, that this reactionary spirit is confined to the few, and that the accession of this new primitive ancestor will be hailed with general satisfaction. At any rate, we can wish him well, and trust that the fossilized jaw of *Dryopithecus* will not lose caste so speedily as that of *Propliopithecus*.

Propliopithecus, or *Dryopithecus?* Hylobatic, or troglodytic affinities? Such questions are scarcely the pivots on which the world is turned! Nevertheless, we rejoice that Doctor Gregory has again settled the former problem (provisorily, at least) to his own satisfaction. More important, however, than that of the dentition of *Dryopithecus*, is the crucial question of whether or not Palæontology is able to furnish evidence of man's genetic continuity with this primitive pithecoid root. Certainly, no effort has been spared to procure the much desired proofs of our reputed bestial ancestry. The Tertiary deposits of Europe, Asia, Africa, America, and the oceanic islands have been diligently ransacked for fossil facts that would be susceptible to an evolutionary interpretation. The aprioristic criterion that all large-brained men are recent, and all small-brained men with recessive chins are necessarily ancient, has always been employed in evaluating the fossil

evidence. Notwithstanding all endeavors, however, to bring about the consummation so devoutly desired, the facts discovered not only fail to support the theory of collateral descent, but actually militate against it. For assuming that man and the anthropoid apes constitute two distinct lines of evolution branching out from common Tertiary or pre-Tertiary stock, palæontology should be able to show numerous intermediate fossil forms, not alone for the lateral branch of the apes, but also, and especially, for the lateral line connecting modern men with the common root of the primate tree. But it is precisely in this latter respect that the fossil evidence for collateral descent fails most egregiously. Palæontology knows of many fossil genera and species of apes and lemurs, that might conceivably represent links in a genetic chain connecting modern monkeys with Tertiary stock, but it has yet to discover so much as a single fossil species, much less a fossil genus, intermediate between man, as we know him, and this alleged Tertiary ancestor common to apes and men.

Not even catastrophism can be invoked to save this irremediable situation; for any catastrophe that would have swept away the human links would likewise have swept away the ape links. The presence of many genera and species of fossil apes, in contrast to the absence of any fossil genus or species of man distinct from *Homo sapiens*, is irreconcilable with the theory of collateral descent. Such is the dilemma proposed to the upholders of this theory by Wasmann, in the 10th chapter of his "Die Moderne Biologie" (3rd edition, 1906), a dilemma, from which, as we shall see, their every attempt to extricate themselves has failed most signally.

"But what," asked Wasmann, "has palæontology to say concerning this question? It tells us that, up to the present, no connecting link between man and the ape has been found; and, indeed, according to the theory of Klaatsch, it is absurd to speak of a link of direct connection between these two forms, but it tells us much more than this. It shows us, on the basis of the results of the most recent research, that we

know the genealogical tree of the various apes, a tree very rich in species, which extends from the present as far back as the hypothetical primitive form assigned to the earliest part of the Tertiary period; and, in fact, in Zittel's work, "Grundzüge der Paläontologie" (1895), not less than thirty genera of fossil Pro-simiæ and eighteen genera of genuine fossil apes are enumerated, the which have been entombed in those strata of the earth that intervene between the Lower Eocene and the Alluvial epoch, but between this hypothetical primitive form and man of the present time we do not find a single connecting link. *The entire genealogical tree of man does not show so much as one fossil genus, or even one fossil species.*" (*Op. cit.*, italics his.) A brief consideration of the principal fossil remains, in which certain palæontologists profess to see evidence of a transition between man and the primitive pithecoid stock, will serve to verify Wasmann's statement, and will reveal the fact that all the alleged connecting links are distinctly human, or purely simian, or merely mismated combinations of human and simian remains.

(1) *Pithecanthropus erectus:* In 1891 Eugène Dubois, a Dutch army surgeon, discovered in Java, at Trinil, in the Ngawa district of the Madiun Residency, a calvarium (skullcap), 2 upper molars and a femur, in the central part of an old river bed. The four fragments, however, were not all found in the same year, because the advent of the rainy season compelled him to suspend the work of excavation. "The teeth," to quote Dubois himself, "were distant from the skull from one to, at most, three meters; the femur was fifteen meters (50 feet) away." (Smithson. Inst. Rpt. for 1898, p. 447.) Dubois judged the lapilli stratum, in which the bones were found, to be older than the Pleistocene, and older, perhaps, than the most recent zones of the *Pliocene* series. "The Trinil ape-man," says Osborn, ". . . is the first of the conundrums of human ancestry. Is the Trinil race prehuman or not?" (*Loc. cit.*, p. 40.) Certainly, Lower Pleistocene, or Upper Pliocene represents too late a time for the appearance of the

upright primate, whence we are said to have sprung. Even Miocene would be too late a date for our alleged divergence from the primitive arboreal stock.

Of the capacity of the calvarium, Dubois says: "I found the above-mentioned cavity measured 550 c.cm. The cast of the cavity of the Neanderthal skull taken to the same plane measures 750 c.cm." (*Loc. cit.*, p. 450, footnote.) His first estimate of the total cranial capacity of *Pithecanthropus* was 1000 c.cm., but, later on, when he decided to reconstruct the skull on the basis of the cranium of a gibbon (*Hylobates agilis*) rather than that of a chimpanzee (*Troglodytes niger*), he reduced his estimate of the cranial capacity to 900 c.cm. Recently, it is rumored, he has increased the latter estimate, as a sequel to his having removed by means of a dentist's tool all the siliceous matter adhering to the skull-cap. As regards shape, the calvarium seems to resemble most closely the cranial vault of gibbon. This similarity, as we have seen, led Dubois to reconstruct the skull on hylobatic lines—"the skull of Hylobates agilis," says Dubois, ". . . strikingly resembles that of Pithecanthropus." (*Loc. cit.*, p. 450, footnote.) The craniologist Macnamara, it is true, claims that the skull-cap most closely approximates the Troglodyte type. Speaking of the calvarium of Pithecanthropus, the latter says: "The cranium of an average adult male chimpanzee and the Java cranium are so closely related that I believe them to belong to the same family of animals—*i.e.* to the true apes." (*Archiv. für Anthropologie,* XXVIII, 1903, pp. 349-360.) The large cranial capacity, however, would seem to favor Dubois' interpretation, seeing that gibbons have, in proportion to their bodies, twice as large a brain as the huge Troglodyte apes, namely, the chimpanzee and the gorilla. The maximum cranial capacity for any ape is from 500 to 600 c.cm. Hence, with 900 c.cm. of cranial capacity estimated by Dubois, the Pithecanthropus stands midway between the ape and the Neanderthal Man, a human dwarf, whose cranial capacity Huxley estimated at 1,236 c.cm. This consideration, however, does

not of itself entitle the Pithecanthropus to be regarded as a connecting link between man and the anthropoid apes. In all such comparisons, it is the *relative*, and not the *absolute*, size of the brain, which is important. The elephant for example, has as large a brain as a man, but the elephant's brain is small, in comparison to its huge body. The brain of a mouse is insignificant, as regards absolute size, but, considered in relation to the size of the mouse's body, it is as large as, if not larger than, that of an elephant, and hence the elephant, for all the absolute magnitude of its brain, is no more "intelligent" than a mouse. As we have already seen, man's brain is unique, not for its absolute size, but for its weight and enormous cortical surface, considered with reference to the comparatively small organism controlled by the brain in question. It is this excess in size which manifests the specialization of the human brain for psychic functions. The Weddas, a dwarf race of Ceylon, have a far smaller cranial capacity than the Neanderthal Man, their average cranial capacity being 960 c.cm., but they are *human pigmies*, whereas the Pithecanthropus, according to Richard Hertwig, was a *giant ape*. "The fragments," says Hertwig, "were regarded by some as belonging to a connecting link between apes and man, *Pithecanthropus erectus Dubois;* by others they were thought to be the remains of genuine apes, and by others those of genuine men. The opinion that is most probably correct is that the fragments belonged to an anthropoid ape of extraordinary size and enormous cranial capacity." ("Lehrbuch der Zoologie," 7th ed.)

Prof. J. H. McGregor essays to make a gradational series out of conjectural brain casts of a large ape, the Pithecanthropus and the Neanderthal Man, in the ratio of 6: 9: 12, this ratio being based upon the estimated cranial capacities of the skulls in question. In a previous chapter, we have seen that such symmetrically graded series have little force as an argument for common descent. In the present instance, however, the gradation gives a wrong impression of the real state

of affairs. If Doctor McGregor had taken into account the all-important consideration of relative size, he would not have been able to construct this misleading series. This consideration, however, did not escape Dubois himself, and in his paper of Dec. 14, 1896, before the Berlin Anthropological Society, he confessed that a gigantic ape of hylobatic type would have a cranial capacity close to that of Pithecanthropus, even if we suppose it to have been no taller than a man. (Cf. Smithson. Inst. Rpt. for 1898, p. 350.) The admission is all the more significant in view of the fact that Dubois was then endeavoring to exclude the possibility of regarding Pithecanthropus as an anthropoid ape.

The teeth, according to Dubois, are unlike the teeth of either men or apes, but according to Virchow and Hrdlička, they are more ape-like than human. The femur, though unquestionably man-like, might conceivably belong to an ape of the gibbon type, inasmuch as the upright posture is more normal to the long-armed gibbon than to any other anthropoid ape, and its thighbone, for this reason, bears the closest resemblance to that of man. According to the "Text-Book of Zoölogy" by Parker and Haswell, the gibbon is the only ape that can walk erectly, which it does, not like other apes, with the fore-limbs used as crutches, but balanced exclusively upon its hind-limbs, with its long arms dangling to the ground—"The Gibbons can walk in an upright position without the assistance of the fore-limbs; in the others, though, in progression on the surface of the ground, the body may be held in a semi-erect position with the weight resting on the hind-limbs, yet the assistance of the long fore-limbs acting as crutches is necessary to enable the animal to swing itself along." (*Op. cit.*, 3rd ed., 1921, vol. II, p. 494.) The Javanese femur is rounder than in man, and is, in this, as well as other respects, more akin to the thighbone of the gibbon. "After examining hundreds of human femora," says Dubois, "Manouvrier could find only two that had a somewhat similar shape. It is therefore a very rare form in man. With the gibbon a similar form

normally occurs." (*Loc. cit.*, pp. 456, 457.) Whether the thighbone really belonged to an erectly walking animal has not yet been definitely settled. To decide this matter, it would be necessary to apply the Walkhoff x-ray method, which determines the mode of progression from the arrangement of the bone fibers in frontal, or other, sections from the femur. This test, however, has not hitherto been made. Nor should the significance of the fact that the thighbone was found at a distance of some *fifty feet away* from the skull-cap be overlooked, seeing that this fact destroys, once and for all, any possibility of *certainty* that both belonged to the same animal.

In conclusion, therefore, we may say that the remains of Pithecanthropus are so scanty, fragmentary, and doubtful, as to preclude a reliable verdict on their true significance. As Virchow pointed out, the determination of their correct taxonomic position is impossible, in the absence of a complete skeleton. Meanwhile, the most probable opinion is that they represent the remains of a giant ape of the hylobatic type. In other words, the Pithecanthropus belongs to the genealogical tree of the apes, and not to that of man. In fact, he has been excluded from the direct line of human descent by Schwalbe, Alsberg, Kollmann, Haacke, Hubrecht, Klaatsch, and all the foremost protagonists of the theory of collateral descent. (Cf. Dwight, *op. cit.*, ch. VIII.) Professor McGregor's series consisting of an ape, the Pithecanthropus, Homo neanderthalensis, and the Crô-Magnon Man fails as an argument, not only for the general reason we have discussed in our third chapter, but also for two special reasons, namely: (1) that he completely ignores the chronological question of the comparative age of the fossils in his series, and (2) that he has neglected to take into account the consideration of the body-brain ratio. For as Prof. G. Grant MacCurdy puts it, "We must distinguish between relative (cranial) capacity and absolute capacity." (Smithson. Inst. Rpt. for 1909, p. 575.) In justice to Professor McGregor, however, it should be noted that he proposes his

interpretation in a purely provisory and tentative sense, and does not dogmatize after the fashion of Osborn and Gregory.

After the year 1896, Dubois appears to have withdrawn the relics of Pithecanthropus from further inspection on the part of scientific men, and to have kept them securely locked up in his safe at Haarlem, Holland. (Cf. *Science,* June 15, 1923, suppl. VIII.) Since all existing casts of the skull-cap of Pithecanthropus are inaccurate, according to the measurements originally given by Dubois, anthropologists were anxious to have access to bones, in order to verify his figures and to obtain better casts. (Cf. Hrdlička, Smithson. Inst. Rpt. for 1913, p. 498.) His obstinate refusal, therefore, to place the Javanese remains at the disposal of scientists was bitterly resented by the latter. Some of them accused him of having become "reactionary" and "orthodox" in his later years, and others went so far as to impugn his good faith in the matter of the discovery. (Cf. W. H. Ballou's article, *North American Review,* April, 1922.) A writer in *Science* says: "It has been rumored that he was influenced by religious bigotry" and refers to the bones as a "skeleton in the closet." (Cf. *loc. cit.*) Dubois' own explanation, however, was that he wished to publish his own finds first. Recently, he seems to have yielded to pressure in the matter, since he permitted Hrdlička, McGregor, and others to examine the fragments of Pithecanthropus. (Cf. *Science,* Aug. 17, 1923, Suppl. VIII.) Meanwhile, too, his opinion has changed with reference to these bones, which he now regards as the remains of a large ape of the hylobatic type, and not of a form intermediate between men and apes. This opinion is, in all likelihood, the correct one.

(2) *The Heidelberg Man:* In a quarry near Mauer in the Elsenz Valley, Germany, on Oct. 21, 1907, a workman engaged in excavating drove his shovel into a fossilized human jaw, severing it into two pieces. Herr Joseph Rösch, the owner of the quarry, immediately telegraphed the news of the find to Prof. Otto Schoetensack of the neighboring University

of Heidelberg. The Professor arrived on the scene the following day, and "once he got hold of the specimen, he would no more let it out of his possession." (Cf. Smithson. Inst. Rpt. for 1913, p. 510.) He took it back with him to Heidelberg, where he cleaned and repaired it. The crowns of four of the teeth broken by the workman's shovel were never recovered. The Heidelberg jaw was found at a depth of about 79 feet below the surface (24.1 meters). Fossil bones of Elephas antiquus, Rhinoceros etruscus, Felis leo fossilis, etc., are said to have been discovered at the same level. The layer in which it was found has been classed by some as Middle Pleistocene, by others as Early Quaternary; for "there seems to be some uncertainty as to the exact subdivision of the period to which it should be attributed." (Hrdlička, *loc. cit.*, p. 516.) No other part of the skeleton except the jaw was discovered.

The teeth are of the normal human pattern, being small and vertical. Prof. Arthur Keith says they have the same shape as those of the specimen found at Spy. The jaw has an ape-like appearance, due to the extreme recessiveness of the chin. It is also remarkable for its massiveness and the broadness of the ascending rami. Its anomalous character is indicated by the manifest disproportion between the powerful jaw and the insignificant teeth. "One is impressed," says Prof. George Grant MacCurdy of Yale, "by the relative smallness of the teeth as compared with the massive jaw in the case of *Homo heidelbergensis*." (Smithson. Inst. Rpt. for 1909, p. 570.) "Why so massive a jaw," says the late Professor Dwight, former anatomist at Harvard, "should have such inefficient teeth is hard to explain, for the very strength of the jaw implies the fitness of corresponding teeth. Either it is an anomaly or the jaw of some aberrant species of ape." (*Op. cit.*, p. 164.) This fact alone destroys its evidential force; for, by way of anomaly, almost any sort of feature can appear in apes and men, that is, human characters in apes and simian characters in man. "Thus it is certain," says Dwight, "that animal features of the most diverse kinds appear in man apparently

without rhyme or reason, and also that they appear in precisely the same way in animals far removed from those in which they are normal. It is hopeless to try to account for them by inheritance; and to call them instances of convergence does not help matters." (*Op. cit.*, pp. 230, 231.)

Kramberger, however, claims that, with the exception of the extremely recessive chin, the features of the Heidelberg jaw are approximated by those which are normal in the modern Eskimo skull. (Cf. *Sitzungbericht der Preuss. Akad. der Wissenschaften,* 1909.) Prof. J. H. McGregor holds similar views. He claims that the greater use of the jaw in uncivilized peoples, who must masticate tough foods, tends to accentuate and increase the recessiveness of the chin. It is also possible that the backward sloping of the chin may have been intensified in certain primitive races or varieties of the human species as a result of factorial mutation. We would not, however, be justified in segregating a distinct human species on the basis of minor differences, such as the protuberance or recessiveness of chins. On the whole, we are hopelessly at sea with reference to the significance of the Heidelberg mandible. Taxonomic allocation must be grounded on something more than a jaw, otherwise it amounts to nothing more than a piece of capricious speculation.

(3) *Eoanthropus Dawsoni:* Dec. 18, 1912, is memorable with evolutionary anthropologists as the day on which Charles Dawson announced his discovery of the famous Dawn Man. The period of discovery extended from the years prior to 1911 up to Aug. 30, 1913, when the canine tooth was found by Father Teilhard de Chardin. The locality was Piltdown Common, Sussex, in England. The fragments recovered were an imperfect cranium, part of the mandible, and the above-mentioned canine tooth. The stratified Piltdown gravel, which Dawson assigns to the Lower Pleistocene or Glacial epoch, had been much disturbed by workmen, "who were digging the gravel for small repairs." (Dawson.) The discoverer first found a fragment of a parietal bone. Then several years later, after the

gravels had been considerably rainwashed, he recovered other fragments of the skull. All parts of the skeletal remains are said to have been found within a radius of several yards from the site of the initial discovery. The skull was reconstructed by Dr. A. Smith Woodward and deposited in the British Museum of Natural History at South Kensington. Eoliths were found in the same gravel as the skull.

Of the skull, according to Woodward, four parts remain, which, however, were integrated from nine fragments of bone. "The human remains," he says, "comprise the greater part of a brain-case and one ramus of the mandible, with two lower molars." Of Woodward's reconstruction, Keith tells us that "an approach to symmetry and a correct adjustment of parts came only after many experimental reconstructions" (cf. "Antiquity of Man," p. 364), and he also remarks that, when Woodward undertook to "replace the missing points of the jaws, the incisor and canine teeth, he followed simian rather than human lines." (*Op. cit.*, p. 324.) Here we may be permitted to observe that, even apart from the distorting influence of preconceived theories, this business of reconstruction is a rather dubious procedure. The absence of parts and the inevitable modification introduced by the use of cement employed to make the fragments cohere make accurate reconstruction an impossibility. The fact that Woodward assigned to the *lower* jaw a tooth which Gerrit Miller of the United States Museum assigns to the *upper* jaw, may well give pause to those credulous persons, who believe that palæontologists can reliably reconstruct a whole cranium or skeleton from the minutest fragments. Sometimes, apparently, the "experts" are at sea even over so simple a question as the proper allocation of a tooth.

Woodward, however, was fully satisfied with his own artistic work on Eoanthropus; for he says: "While the skull, indeed, is evidently human, only approaching a lower grade in certain characters of the brain, in the attachment for the neck, the extent of the temporal muscles and in the probable size of the

face, the mandible appears to be almost precisely that of an ape, with nothing human except the molar teeth." (Cf. Smithson. Inst. Rpt. for 1913, pp. 505, 506.) Of the cranial capacity Woodward gives the following estimate: "The capacity of the brain-case cannot, of course, be exactly determined; but measurements both by millet seed and water show that it must have been at least 1,070 cc., while a consideration of the missing parts suggests that it may have been a little more (note the parsimoniousness of this concession!). It therefore agrees closely with the capacity of the Gibraltar skull, as determined by Professor Keith, and equals that of the lowest skulls of the existing Australians. It is much below the Mousterian skulls from Spy and La Chapelle-aux-Saints." (*Loc. cit.*, p. 505.)

Where Doctor Woodward came to grief, however, was in his failure to discern the obvious disproportion between the mismated cranium and mandible. As a matter of fact, the mandible is older than the skull and belongs to a fossil ape, whereas the cranium is more recent and is conspicuously human. Woodward, however, was blissfully unconscious of this mésalliance. What there is of the lower jaw, he assures us, "shows the same mineralized condition as the skull" and "corresponds sufficiently well in size to be referred to the same individual without any hesitation." (*Loc. cit.*, p. 506.)

For this he was roundly taken to task by Prof. David Waterston in an address delivered by the latter before the London Geological Society, Dec., 1912. *Nature,* the English scientific weekly, reports this criticism as follows: "To refer the mandible and the cranium to the same individual would be equivalent to articulating a chimpanzee foot with the bones of a human thigh and leg." Prof. J. H. McGregor of Columbia, though he followed Woodward in modeling the head of Eoanthropus now exhibited in "The Hall of the Age of Man," told the writer that he believed the jaw and the skull to be misfits. Recently, Hrdlička has come out strongly for the separation of the mandible from the cranium, insisting that the former is *older* and on the order of the jaw of the

fossil ape *Dryopithecus,* while the skull is less antique and indubitably human. The following abstract of Hrdlička's view is given in *Science,* May 4, 1923: "Dr. Hrdlička," we read, "holds that the Piltdown jaw is much older than the skull found near it and to which it had been supposed to belong." (Cf. suppl. X.) Hrdlička asserts that, from the standpoint of dentition, there is a striking resemblance between the Piltdown jaw and that of the extinct ape *Dryopithecus rhenanus.* He comments, in fact, on "the close relation of the Piltdown molars to some of the Miocene or early Pliocene human-like teeth of this fossil ape." (*Ibidem.*) Still other authorities, however, have claimed that the jaw was that of a chimpanzee.

To conclude, therefore, the Eoanthropus Dawsoni is an invention, and not a discovery, an artistic creation, not a specimen. Anyone can combine a simian mandible with a human cranium, and, if the discovery of a connecting link entails no more than this, then there is no reason why evidence of human evolution should not be turned out wholesale.

(4) *The Neanderthal Man* (No. 1): The remains of the famous Neanderthal Man were found in August, 1856, by two laborers at work in the Feldhofer Grotte, a small cave about 100 feet from the Düssel river, near Hochdal in Germany. This cave is located at the entrance of the Neanderthal gorge in Westphalia, at a height of 60 feet above the bottom of the valley. No competent scientist, however, saw the bones *in situ.* Both the bones and the loam, in which they were entombed, had been thrown out of the cave and partly precipitated into the ravine, long before the scientists arrived. Indeed, the scientific discoverer, Dr. C. Fuhlrott, did not come upon the scene until several weeks later. It was then too late to determine the age of the bones geologically and stratigraphically, and no petrigraphic examination of the loam was made. The cave, which is about 25 meters above the level of the river, communicates by crevices with the surface, so that it is possible that the bones and the loam, which covered the floor of the cave, may have been washed in from without. Fuhlrott

recovered a skull-cap, two femurs, both humeri, both ulnæ (almost complete), the right radius, the left pelvic bone, a fragment of the right scapula, five pieces of rib, and the right clavicle. (Cf. Hugues Obermaier's article, Smithson. Inst. Rpt. for 1906, pp. 394, 395.) "Whether they (the (bones) were really in the Alluvial loam," says Virchow, "no one saw. . . . The whole importance of the Neanderthal skull consists in the honor ascribed to it from the very beginning, of having rested in the Alluvial loam, which was formed at the time of the early mammals." (Quoted by Ranke, "Der Mensch," II, p. 485.) We know nothing, therefore, regarding the age of the fragmentary skeleton; for, as Obermaier says: "It is certain that its exact age is in no way defined, either geologically or stratigraphically." (*Loc. cit.*, p. 395.)

The remains are no less enigmatic from the anthropological standpoint. For while no doubt has been raised as to their human character, they have given rise to at least a dozen conflicting opinions. Thus Professor Clemont of Bonn pronounced the remains in question to be those of a Mongolian Cossack shot by snipers in 1814, and cast by his slayers into the Feldhofer Grotte. The same verdict had been given by L. Meyer in 1864. C. Carter Blake (1864) and Karl Vogt (1863) declared the skull to be that of an idiot. J. Barnard Davis (1864) claimed that it had been artificially deformed by early obliteration of the cranial sutures. Pruner-Bey (1863) said that it was the skull of an ancient Celt or German; R. Wagner (1864), that it belonged to an ancient Hollander; Rudolf Virchow, that the remains were those of a primitive Frieslander. Prof. G. Schwalbe of Strassburg erected it into a new *genus* of the *Anthropidæ* in 1901. In 1904, however, he repented of his rashness and contented himself with calling it a distinct human *species*, namely, *Homo primigenius*, in contradistinction to *Homo sapiens* (modern man). As we shall see presently, however, it is not a distinct species, but, at most, an ancient *variety* or *subspecies* (race) of the species *Homo sapiens*, differing from modern Europeans

only in the degree that Polynesians, Mongolians, and Hottentots differ from them, that is, within the limits of the one and only human species. Other opinions might be cited (cf. Hrdlička, Smithson. Inst. Rpt. for 1913, p. 518, and H. Muckermann's "Darwinism and Evolution," 1906, pp. 63, 64), but the number and variety of the foregoing bear ample testimony to the uncertain and ambiguous character of the remains.

The skull is that of a low, perhaps, degenerate, type of humanity. The facial and basal parts of the skull are missing. Hence we are not sure of the prognathism shown in McGregor's reconstruction. The skull has, however, a retreating forehead, prominent brow ridges and a sloping occiput. Yet, in spite of the fact that it is of a very low type, it is indubitably human. "In no sense," says Huxley, "can the Neanderthal bones be regarded as the remains of a human being intermediate between men and apes." ("Evidence of Man's Place in Nature," Humb. ed., p. 253.) D. Schaaffhausen makes the same confession—"In making this discovery," he owns, "we have not found the missing link." ("Der Neanderthaler Fund," p. 49.) The cranial capacity of the Neanderthal skull, as we have seen, is 1,236 c.cm., which is practically the same as that of the average European woman of to-day. In size it exceeds, but in shape it resembles, the dolichocephalic skull of the modern Australian, being itself a dolichocephalic cranium. Huxley called attention to this resemblance, and Macnamara, after comparing it with a large number of such skulls, reaches this conclusion: "The average cranial capacity of these selected 36 skulls (namely, of Australian and Tasmanian blacks) is even less than that of the Neanderthal group, but in shape some of these two groups are closely related." (*Archiv. für Anthropologie,* XXVIII, 1903, p. 358.) Schwalbe's opinion that the Neanderthal Man constitutes a distinct species, though its author has since abandoned it (cf. Wasmann's "Modern Biology," Eng. ed., 1910, p. 506), will be considered later, viz. after we have discussed the Men of Spy, Krapina

and Le Moustier, all of whom have been assigned to the Neanderthal group.

(5) *Neanderthal Man* (No. 2): This specimen is said to be more recent than No. 1. Its discoverers were Rautert, Klaatsch, and Koenen. It consists of a human skeleton without a skull. It was found buried in the loess at a depth of 50 centimeters. This loess had been washed into the ruined cave, where the relics were found, subsequently to its deposition on the plateau above. The bones were most probably washed into the cave along with the loess, which fills the remnant of the destroyed cave. The upper plateau of the region is covered with the same loess. The site of the second discovery was 200 meters to the west of the Neanderthal Cave (*i.e.* the Feldhofer Grotte). The bones were either washed into the broken cave, or buried there later. We have no indication whatever of their age.

(6) *The Man of La Naulette:* In 1866, André Dupont found in the cavern of La Naulette, valley of the Lesse, Belgium, a fossil lower jaw, or rather, the fragment of a lower jaw, associated with remains of the mammoth and rhinoceros. The fragment was sufficient to show the dentition, and to indicate the absence of a chin. "Its kinship with the man of Neanderthal," remarks Professor MacCurdy very naïvely, "whose lower jaw could not be found, was evident. It tended to legitimatize the latter, which hitherto had failed of general recognition." (Smithson. Inst. Rpt. for 1909, p. 572.)

(7) *The Men of Spy:* In June of 1886 two nearly complete skeletons, probably of a woman and a man, were discovered by Messrs. Marcel de Puydt and Maximin Lohest in a terrace fronting a cave at Spy in the Province of Namur, Belgium, 47½ feet above the shallow bed of the stream Orneau. The bones were found at a depth of 13 feet below the surface of the terrace. The remains were associated with bones of the rhinoceros (*Rhinoceros tichorhinus*), the mammoth (*Elephas primigenius*), and the great bear (*Ursus spelaeus*). There were also stone implements indicating Mousterian industry, and the

position of one of the skeletons shows that the bodies were buried by friends. The present valley of the Orneau was almost completely formed at the time of the burial. The exact age of the bones cannot be determined nor can these cave deposits be correlated with the river drift and the loess. The cultural evidences are said to be Mousterian, and Mousterian culture is assigned by Obermaier to the Fourth, or last, Glacial period.

Prof. Julien Fraipont of the University of Liége announced the discovery of these palæolithic skeletons Aug. 16, 1886. Skeleton No. 1 has weaker bones and is thought to be that of a woman; No. 2 shows signs of strong musculature and is evidently that of a man. Of No. 1 we have the cranial vault, two portions of the upper jaw (with five molars and four other teeth), a nearly complete mandible with all the teeth, a left clavicle, a right humerus, the shaft of the left humerus, a left radius, the heads of two ulnæ, a nearly complete right femur, a complete left tibia, and the right os calcis. Of No. 2 we have the vault of the skull, two portions of the maxilla with teeth, loose teeth belonging to lower jaw, fragments of the scapulæ, the left clavicle, imperfect humeri, the shaft of the right radius, a left femur, the left os calcis, and the left astragalus. The separation of the bones, however, is not yet satisfactory. The jaw of No. 1 is well-preserved, except in the region of the coronoids and condyles, which makes any position we may give it more or less arbitrary. The skull of this specimen is almost the replica of the Neanderthal skull, except that the forehead is lower and more sloping. But No. 1 has a trace of chin prominence and in this it resembles modern skulls. No. 2 has a higher forehead and the cranial vault is higher and more spacious.

In both skeletons the radius and femur show a peculiar curvature, and in both, too, the arms and legs must have been very short. Hence the men of Spy are described as having been only partially erect, and as having had bowed thighs and bent knees. The source of this modification, however, is not a sur-

viving pithecoid atavism, but a non-inheritable adaptation acquired through the habitual attitude or posture maintained in stalking game—"Now we know," says Dwight, "that this feature, which is certainly an ape-like one, implies simply that the race was one of those with the habit of 'squatting,' which implies that the body hangs from the knees, not touching the ground for hours together. As a matter of course we look for this in savage tribes." ("Thoughts of a Catholic Anatomist," p. 168.) The same may be said of the receding chin, which, as we have seen, is also an acquired adaptation. The same, finally, is true of the prominent brow ridges, which are not pithecoid, but are, as Klaatsch has pointed out, related to the size of the eye sockets, and consequently the result of an adaptation of early palæolithic man to the life of a hunter, a natural sequel of the very marked development of his sense of sight. Similar brow ridges, though not quite so prominent, occur among modern Australian blacks.

Nor are the remains as typically Neanderthaloid as Keith and others (who wish to see in palæolithic men a distinct human species) could desire. No. 1, as we have seen, though almost a replica of the Neanderthal skull-cap, has a trace of chin prominence in the mandible. No. 2, though the chin is recessive, has a higher forehead and higher and more spacious cranial vault than the Neanderthal Man. "On the whole," says Hrdlička, "it may be said that No. 2, while in some respects still very primitive, represents morphologically a decided step from the Neanderthaloid to the present-day type of the human cranium." (Smithson. Inst. Rpt. for 1913, p. 525.)

(8) *The Men of Krapina:* In the cave, or rather rock shelter, of Krapina, in northern Croatia, beside the small stream Kaprinica which now flows 82 feet below the cave, K. Gorjanovič-Kramberger, Professor of geology and palæontology at the University of Zagreb, found, in the year 1899, ten or twelve skulls in fragments, a large number of teeth, and many other defective parts of skeletons. All told, they represent at

least fourteen different individuals. The bones are in a bad state of preservation, and show traces of burning, some of them being calcined. The bones were associated with objects of Mousterian industry, and bones of extinct animals such as *Rhinoceros merckii, Ursus spelaeus, Bos primigenius,* etc. The aforesaid Rhinoceros is an older type than the *Rhinoceros trichorhinus* associated with the men of Spy, and implies a hot climate, wherein the *Rhinoceros merckii* managed to persist for a longer time than in the north. Hence the remains are thought to belong to the last Interglacial period.

In general, the bones show the same racial characteristics as those of Neanderthal and Spy, though they are said to be of a perceptibly more modern type than the latter. They were men of short stature and strong muscular development. "The crania," says Hrdlička, "were of good size externally, but the brain cavities were probably below the present average. The vault of the skull was of good length and at the same time fairly broad, so that the cephalic index, at least in some of the individuals, was more elevated than usual in the crania of early man." (*Loc. cit.*, pp. 530, 531.) The reader must take Hrdlička's use of the word "usual" with "the grain of salt" necessitated in view of the scanty number of specimens whence such inductive generalizations are derived. The pronounced and complete supraorbital arcs characteristic of the Neanderthaloid type occur in this group also, though in a less marked manner. The stone implements are evidence of the intelligence of these men.

(9) *The Le Moustier Man:* This specimen, *Homo mousteriensis Hauseri,* was found by Prof. O. Hauser in the "lower Moustier Cave" at Le Moustier in the valley of the Vézère, Department of Dordogne in France, during the March of 1908. It consists of the complete skull and other skeletal parts of a youth of about 15 years. At this age, the sex cannot be determined from the bones alone. Obermaier assigns these bones to the Fourth Glacial period. Prof. George Grant MacCurdy's anthropological evaluation is the following: "The race

characters . . . are not so distinct (*i.e.* at the age of 15 years) as they would be at full maturity; but they point unmistakably to the type of Neanderthal, Spy, and Krapina—the so-called *Homo primigenius* which now also becomes *Homo mousteriensis*. It was a rather stocky type, robust and of a low stature. The arms and legs were relatively short, especially the forearm and from the knee down, as is the case among the Eskimo. Ape-like characters are noticeable in the curvature of the radius and of the femur, the latter being also rounder in section than is the case with *Homo sapiens*. In the retreating forehead, prominent brow ridges, and prognathism (*i.e.* projection of the jaws) it is approached to some extent by the modern Australian. The industry associated with this skeleton is that typical of the Mousterian epoch." (*Loc. cit.*, p. 573.) As we have already seen, the so-called ape-like features are simply acquired adaptations to the hunter's life, and, if inheritable characters, they do not exceed the limits of a varietal mutation. That the Mousterian men were endowed with the same intelligence as ourselves, appears from the evidences of solemn burial which surround the remains of this youth of 15 years, and prove, as Klaatsch points out, that these men of the Glacial period were persuaded of their own immortality. The head reclined on a pillow of earth, which still retains the impression of the youth's cheek, the body having been laid on its side. Around the corpse are the best examples of the stone implements of the period, the parents having buried their choicest possession with the corpse of their son.

(10) *The La Chapelle Man:* On August 3, 1908, the Abbés J. and A. Bouyssonie and L. Bardon, assisted by Paul Bouyssonie (a younger brother of the first two), discovered palæolithic human remains, which are also assigned to the Neanderthal group. The locality of the discovery was the village of La Chapelle-aux-Saints, 22 kilometers south of the town of Brive, in the department of Corrèze, in southern France. In the side of a moderate elevation, 200 yards south of the aforesaid village, and beyond the left bank of a small stream, the

Sourdoire, there is a cave now known as the Cave of La Chapelle-aux-Saints. It was here, on the above-mentioned date, that the priests discovered the bones of a human skeleton surrounded by unmistakable evidences of solemn burial. "The body lay on its back, with the head to the westward, the latter being surrounded by stones. . . . About the body were many flakes of quartz and flint, some fragments of ochre, broken animal bones, etc." (Hrdlička.) Another token of burial is the rectangular pit, in which the remains were found. It is sunk to a depth of 30 to 40 centimeters in the floor of the cavern.

"They (the remains) were covered," says Prof. G. G. MacCurdy, "by a deposit intact 30 to 40 centimeters thick, consisting of a magma of bone, of stone implements, and of clay. The stone implements belong to a pure Mousterian industry. While some pieces suggest a vague survival of Acheulian implements (*i.e.* from the cool latter half of the Third Interglacial period), others presage the coming of the Aurignacian (close of last Glacial period). Directly over the human skull were the foot bones, still in connection, of a bison—proof that the piece had been placed there with the flesh still on, and proof, too, that the deposit had not been disturbed. Two hearths were noted also, and the fact that there were no implements of bone, the industry differing in this respect from that of La Quina and Petit-Puymoyen (Charente), as well as at Wildkirchli, Switzerland.

"The human bones include the cranium and lower jaw (broken, but the pieces nearly all present and easily replaced in exact position), a few vertebræ and long bones, several ribs, phalanges, and metacarpals, clavicle, astragalus, calcaneum, parts of scaphoid, ilium, and sacrum. The ensemble denotes an individual of the male sex whose height was about 1.60 meters. The condition of the sutures and of the jaws proves the skull to be that of an old man. The cranium is dolichocephalic, with an index of 75. It is said to be flatter in the frontal region than those of Neanderthal and Spy." (*Loc. cit.*, p. 574.)

The associated remains of fossil animals comprise the horse, reindeer, bison, *Rhinoceros tichorinus,* etc., and, according to Hrdlička, "indicate that the deposits date from somewhere near the middle of the glacial epoch." (*Loc. cit.,* p. 539.) The discoverers turned over the skeleton to Marcellin Boule of the Paris Museum of Natural History for cleaning and reconstruction. It is the *first instance* of a palæolithic man, in which *the basal parts* of the skull, including the foramen magnum, were recovered. Professor Boule estimates the cranial capacity as being something between 1,600 and 1,620 c.cm. He found the lower part of the face to be prognathic, but not excessively so, the vault like the Neanderthal cranium, but larger, the occiput broad and protruding, the supraorbital arch prominent and complete, the nasal process broad, the forehead low, and the mandible stout and chinless, though not sloping backward at the symphysis.

Alluding to the rectangular burial pit in the cave, Hrdlička remarks: "The depression was clearly made by the primitive inhabitants or visitors of the cave for the body and the whole represents very plainly a regular burial, the most ancient intentional burial thus far discovered." (Smithson. Inst. Rpt. for 1913, p. 539.)

The specimens of Neanderthal, Spy, La Naulette, Krapina, Le Moustier and La Chapelle, as we have seen, are the principal remains said to represent the Neanderthal type, which, according to Keith and others, is a distinct human species. As Aurignacian Man (assigned to the close of the "Old Stone Age," or Glacial epoch), including the Grimaldi or Negroid as well as the Crô-Magnon type, are universally acknowledged to belong to the species *Homo sapiens,* we need not discuss them here. The same holds true, *a fortiori,* of Neolithic races such as the Solutreans and the Magdalenians. The main issue for the present is whether or not the Neanderthal type represents a *distinct species* of human being.

Anent this question, Professor MacCurdy has the following: "Boule estimated the capacity of the Chapelle-aux-Saints

skull according to the formulæ of Manouvrier, of Lee, and of Beddoe, obtaining results that varied between 1,570 and 1,750 cubic centimeters. By the use of millet and of shot an average capacity of 1,626 was obtained. Judging from these figures the capacity of the crania of Neanderthal and Spy has been underestimated by Schaaffhausen, Huxley, and Schwalbe. By its cranial capacity, therefore, the Neanderthal race belongs easily in the class of *Homo sapiens*. But we must distinguish between relative capacity and absolute capacity. In modern man, where the transverse and antero-posterior diameters are the same as in the skull of La Chapelle-aux-Saints, the vertical diameter would be much greater, which would increase the capacity to 1,800 cubic centimeters and even to 1,900 cubic centimeters. Such voluminous modern crania are very rare. Thus Bismarck, with horizontal cranial diameters scarcely greater than in the man of La Chapelle-aux-Saints, is said to have had a cranial capacity of 1,965 cubic centimeters." (Smithson. Inst. Rpt. for 1909, p. 575.)

As for the structural features which are alleged to constitute a *specific difference* between the Neanderthal type and modern man, *v.g.* the prominent brow ridges, prognathism, retreating forehead, receding chin, etc., all of these occur, albeit in a lesser degree, in modern Australian blacks, who are universally acknowledged to belong to the species *Homo sapiens*. Moreover, there is much *fluctuation*, as Kramberger has shown from the examination of an enormous number of modern and fossil skulls, in both the Neanderthal and the modern type; that is to say, Neanderthaloid features occur in modern skulls and, conversely, modern features occur in the skulls of *Homo neanderthalensis* (cf. "Biolog. Zentralblatt," 1905, p. 810; and Wasmann's "Modern Biology," Eng. ed., pp. 472, 473).

All the differences between modern and palæolithic man are explicable, partly upon the basis of *acquired adaptation*, inasmuch as the primitive mode of life pursued by the latter entailed the formation of body-modifying habits very different

from our present customs and habits (viz. those of our modern civilized life). But these modifications, not being inheritable, passed away with the passing of the habits that gave rise to them. In part, however, the differences may be due to heritable *mutations*, which gave rise to new *races* or *varieties* or *subspecies*, such as Indo-Europeans, Mongolians, and Negroes. And, if the evolutionary palæontologist insists on magnifying characters that are well within the scope of mere factorial mutation into a specific difference, we shall reply, with Bateson and Morgan, by denying his competence to pronounce on taxonomic questions, without consulting the verdict of the geneticist. Without breeding tests, the criterions of intersterility and longevity cannot be applied, and breeding tests are impossible in the case of fossils. As for an *a priori* verdict, no modern geneticist, if called upon to give his opinion, would concede that the differences which divide the modern and the Neanderthal types of men exceed the limits of factorial mutations, or of natural varieties within the same species. Here, then, it is a case of the wish being father to the thought. So anxious are the materialistic evolutionists to secure evidence of a connection between man and the brute, that no pretext is too insignificant to serve as warrant for recognizing an "intermediate species."

Even waiving this point, however, there is no evidence at all that the Neanderthal type is ancestral to the Crô-Magnon type. Both of these races must have migrated into Europe from the east or the south, and we have no proof whatever of genetic relationship between them. True, attempts have been made to capitalize the fact that the Neanderthal race was represented by specimens discovered in what were alleged to be the older deposits of the Glacial epoch, but we have seen that the evidences of antiquity are very precarious in the case of these Neanderthaloid skeletons. Time-scales based on extinct species and characteristic stone implements, etc., are always satisfactory to evolutionists, because they can *date* their fossils and archæological cultures *according to the theory*

of evolution, but, for one whose confidence in the "reality" of evolution is not so great, these palæontological chronometers are open to grave suspicion.

If the horizon levels are not too finely graded, the difficulty of accepting such a time-scale is not excessive. Hence we might be prepared to accept the chronometric value of the division of fossiliferous rocks into Groups, such as the Palæozoic, the Mesozoic, and the Cænozoic, even though we are assured by Grabau that this time-scale is "based on the changes of life, with the result that fossils alone determine whether a formation belongs to one or the other of these great divisions" ("Principles of Stratigraphy," p. 1103), but when it comes to projecting an elaborate scheme of levels or horizons into Pleistocene deposits on the dubious basis of index fossils and "industries," our credulity is not equal to the demands that are made upon it. And this is particularly true with reference to fossil men. Man has the geologically unfortunate habit of *burying his dead.* Other fossils have been entombed on the spot where they died, and therefore belong where we find them. But it is otherwise with man. In Hilo, Hawaii, the writer heard of a Kanaka, who was buried to a depth of 80 feet, having stipulated this sort of burial through a special disposition in his will. His purpose, in so doing, was to preclude the possibility of his bones ever being disturbed by a plough or other instrument. Nor have we any right to assume that indications of burial will always be present in a case of this nature. We may, on the contrary, assume it as a general rule that human remains are always more recent than the formations in which they are found.

Be that as it may, the evidences for the antiquity of the Neanderthaloid man prove, at most, that he was prior to the Crô-Magnon man in Europe, but they do not prove that the former was prior to the latter absolutely. Things may, for all we know, have been just the reverse in Asia. Hence we have no ground for regarding the Man of Neanderthal as ancestral to the race of artists, who frescoed the caves of France and

Spain. In fact, to the unprejudiced mind the Neanderthal type conveys the impression of a race on the downward path of degeneration rather than an embodiment of the promise of better things. "There is another view," says Dwight, ". . . though it is so at variance with the Zeitgeist that little is heard of it. May it not be that many low forms of man, archaic as well as contemporary, are degenerate races? We are told everything about progress; but decline is put aside. It is impossible to construct a tolerable scheme of ascent among the races of man; but cannot dark points be made light by this theory of degeneration? One of the most obscure, and to me most attractive of questions, is the wiping out of old civilizations. That it has occurred repeatedly, and on very extensive scales, is as certain as any fact in history. Why is it not reasonable to believe that bodily degeneration took place in those fallen from a higher estate, who, half-starved and degraded, returned to savagery? Moreover, the workings of the soul would be hampered by a degenerating brain. For my part I believe the Neanderthal man to be a specimen of a race, not arrested in its upward climb, but thrown down from a higher position." (*Op. cit.*, pp. 169, 170.)

The view, however, that the Neanderthaloid type had degenerated from a previous higher human type was not at all in accord with the then prevalent opinion that this type was far more ancient than any other. And Dwight himself admitted the force of the "objection . . . that the Neanderthal race was an excessively old one and that skeletons of the higher race which, according to the view which I have offered, must have existed at the same time as the degenerate ones, are still to be discovered." (*Op. cit.*, p. 170.) In fact, the Neanderthal ancestry of the present human race was so generally accepted that, in the very year in which Dwight's book appeared, Sir Arthur Keith declared: "The Neanderthal type represents the stock from which all modern races have arisen." Time, however, as Dr. James Walsh remarked (*America*, Dec. 15, 1917, pp. 230, 231), has triumphantly vin-

dicated the expectations of Professor Dwight. For in his latest book, "The Antiquity of Man" (1916), Sir Arthur Keith has a chapter of Conclusions, in which the following recantation appears: "We were compelled to admit," he owns, "that men of the modern type had been in existence long before the Neanderthal type."

But, even if it were true that savagery preceded civilization in Europe, such could not have been the case everywhere; for it is certain that civilization and culture of a comparatively high order were imported into Europe before the close of the Old Stone Age. The Hungarian Lake-dwellings show that culture of a high type existed in the New Stone Age. These two ages are regarded as prehistoric in Europe, though in America the Stone Age belongs to history. It is also possible that in Europe much of the Stone Age was coëval with the history of civilized nations, and that it may be coincident with, instead of prior to, the Bronze Age, which seems to have begun in Egypt, and which belongs unquestionably to history. And here we may be permitted to remark that history gives the lie to the evolutionary conceit that civilized man has arisen from a primitive state of barbarism. History begins almost contemporaneously in many different centers, such as Egypt, Babylonia, Chaldea, China, and Crete, about 5,000 or 6,000 years ago, and, as far back as history goes, we find the record of high civilizations existing side by side with a coëval barbarism. Barbarism is historically a state of degeneration and stagnation, and history knows of no instance of a people sunk in barbarism elevating itself by its own efforts to higher stages of civilization. Always civilization has been imposed upon barbarians from without. Savages, so far as history knows them, have never become civilized, save through the intervention of some contemporary civilized nation. History is one long refutation of the Darwinian theory of constant and inevitable progress. The progress of civilization is not subsequent, but prior, or parallel, to the retrogression of barbarism.

That savagery and barbarism represent a *degenerate,* rather than a *primitive,* state, is proved by the fact that savage tribes, in general, despite their brutish degradation, possess languages too perfectly elaborated and systematized to be accounted for by the mental attainments of the men who now use them, languages which testify unmistakably to the superior intellectual and cultural level of their civilized ancestors, to whom the initial construction of such marvelous means of communication was due. "It is indeed one of the paradoxes of linguistic science," says Dr. Edwin Sapir, in a lecture delivered April 1, 1911, at the University of Pennsylvania, "that some of the most complexly organized languages are spoken by so-called primitive peoples, while, on the other hand, not a few languages of relatively simple structure are found among peoples of considerable advance in culture. Relatively to the modern inhabitants of England, to cite but one instance out of an indefinitely large number, the Eskimos must be considered as rather limited in cultural development. Yet there is just as little doubt that in complexity of form the Eskimo language goes far beyond English. I wish merely to indicate that, however we may indulge in speaking of primitive man, of a primitive language in the true sense of the word we find nowhere a trace." (Smithson. Inst. Rpt. for 1912, p. 573.) Pierre Duponceau makes a similar observation with reference to the logical and orderly organization of the Indian languages: "The dialects of the Indian tribes," he says, "appear to be the work of philosophers rather than of savages." (Cited by F. A. Tholuck, "Verm. Schr.," ii, p. 260.)

It was considerations of this sort which led the great philologist Max Müller to ridicule Darwin's conception of primitive man as a savage. "As far as we can trace the footsteps of man," he writes, "even on the lowest strata of history, we see that the Divine gift of a sound and sober intellect belonged to him from the very first; and the idea of humanity emerging slowly from the depths of an animal brutality can

never be maintained again in our century. The earliest work of art wrought by the human mind—more ancient than any literary document, and prior even to the first whisperings of tradition—the human language, forms one uninterrupted chain, from the first dawn of history down to our own times. We still speak the language of the first ancestors of our race; and this language with its wonderful structures, bears witness against such gratuitous theories. The formation of language, the composition of roots, the gradual discrimination of meanings, the systematic elaboration of grammatic forms—all this working which we can see under the surface of our own speech attests from the very first the presence of a rational mind, of an artist as great at least as his work." ("Essays," vol. I, p. 306.) History and philology are far more solid and certain as a basis for inference than are "index fossils" and prehistoric archæology; and the lesson taught by history and philology is that primitive man was not a savage, but a cultured being endowed with an intellect equal, if not superior, to our own.

But, even if we grant the priority, which evolutionists claim for the Old Stone Age, there are not absent even from that cultural level evident tokens of artistic genius and high intellectual gifts. Speaking of the pictures in the caves of Altamira, of Marsoulas in the Haute Garonne, and of Fonte de Gaume in the Dordogne, the archæologist Sir Arthur Evans says: "These primeval frescoes display not only consummate mastery of natural design, but an extraordinary technical resource. Apart from the charcoal used in certain outlines, the chief coloring matter was red and yellow ochre, mortars and palettes for the preparation of which have come to light. In single animals the tints varied from black to dark and ruddy brown or brilliant orange, and so, by fine gradations, to paler nuances, obtained by scraping and washing. Outlines and details are brought out by white incised lines, and the artists availed themselves with great skill of the reliefs afforded by convexities of the rock surface. But the greatest marvel of all

is that such polychrome masterpieces as the bisons, standing and couchant, or with limbs huddled together, of the Altamira Cave, were executed on the ceilings of inner vaults and galleries where the light of day has never penetrated. Nowhere is there any trace of smoke, and it is clear that great progress in the art of artificial illumination had already been made. We know that stone lamps, decorated in one case with the engraved head of an ibex, were already in existence. Such was the level of artistic attainment in southwestern Europe, at a modest estimate, some 10,000 years earlier than the most ancient monuments of Egypt or Chaldæa!" (Smithson. Inst. Rpt. for 1916, pp. 429, 430.) While reaffirming our distrust of the undocumented chronology of "prehistory," we cite these examples of palæolithic art as a proof of the fact that everywhere the manifestation of man's physical presence coincides with the manifestation of his intelligence, and that neither in history nor in prehistory have we any evidence of the existence of a bestial or irrational man preceding *Homo sapiens*, as we know him to-day. It is interesting to note in this connection that a certain J. Taylor claims to have found a prehistoric engraving of a mastodon on a bone found in a rock shelter known as Jacobs' Cavern in Missouri (cf. *Science*, Oct. 14, 1921, p. 357). Incidents of this sort must needs dampen the enthusiasm of those who are overeager to believe in the enormous antiquity of the Old Stone Age in Europe.

(11) *The Rhodesian Man:* In 1921 a human skull was found by miners in the "Bone Cave" of the Broken Hill Mine in southern Rhodesia. It was associated with human and animal bones, as well as very crude instruments (knives and scrapers) in flint and quartz. It was found at a depth of 60 feet below the surface. The lower jaw was missing, and has not been recovered. It was sent to the British Museum, South Kensington, where it is now preserved. Doctor Smith-Woodward has examined and described it. "The skull is in some features the most primitive one that has ever been found; at the same time it has many points of resemblance to (or even identity

with) that of modern man." (*Science*, Feb. 3, 1922, p. 129.) The face is intact. The forehead is low, and the brow ridges are more pronounced than in any known fossil human skull. The prognathism of the upper jaw is very accentuated. The cranium is very flat on top and broad in the back. "Its total capacity is surprisingly large. At least one prominent authority thinks that this man had quite as much gray matter as the average modern man." (*Loc. cit.*, pp. 129, 130.) Woodward, however, estimates the cranial capacity of this skull as 1280 c.cm. The neck must have had powerful muscles. The nasal bone is prominent and Neanderthaloid in character. "The wisdom tooth is reduced in size—another point in common with modern man and never found before in a fossil skull." (*Ibidem.*) The palate and the teeth in general are like those of existing men. The femur is not curved like that of the Neanderthal man—"In contrast to the Neanderthal man who is supposed to have walked in a crouching position (because of the rather curved femur and other bits of evidence), this man is believed to have maintained the upright position, because the femur is relatively straight and when fitted to the tibia (which was also found) presents a perfectly good, straight leg." (*Ibidem.*) According to the writer we have quoted, Dr. Elliot Smith entertained hopes that the Rhodesian man might represent the "missing link" in man's ancestry, leaving the Neanderthal man as an offshoot from the main ancestral trunk. No comment is necessary. The skull may be a pathological specimen, but, in any case, it is evidently human as regards its cranial capacity. The remains, moreover, serve to emphasize the *fluctuational* character of the so-called *Homo primigenius* type, being a mixture of modern and Neanderthaloid features. They are not fossilized and present a recent appearance. Hence, as B. Windle suggests, they may have fallen into the cave through a crack, and may be modern rather than prehistoric.

(12) *The Foxhall Man:* This is the earliest known prehistoric man. He is known to us, however, only through "his

flint instruments partly burned with fire, found near the little hamlet of Foxhall, near Norwich, on the east coast of England. These flints, discovered in 1921, constitute the first proofs that man of sufficient intelligence to make a variety of flint implements and to use fire existed in Britain at the close of the Age of Mammals; this is the first true Tertiary man ever found." (Osborn: *Guide-leaflet* to "The Hall of the Age of Man," 2nd ed., 1923, p. 9.) Osborn assigns the twelve kinds of flint instruments typical of the Foxhallian culture to the Upper Pliocene epoch. R. A. Macalister, however, denies that the deposits are Tertiary. Abbé Henri Breuil's verdict was undecided. In any case, the Foxhallian culture proves that the earliest of prehistoric men were intelligent like ourselves.

Summa summarum: So far as science knows, only one human species has ever existed on the earth, and that is *Homo sapiens*. All the alleged connecting links between men and apes are found, on careful examination, to be illusory. When not wholly ambiguous in view of their inadequate preservation and fragmentary character, they are (as regards both mind and body) distinctly human, like the Neanderthal man, or they are purely simian, like the Pithecanthropus, or they are heterogeneous combinations of human and simian bones, like the Eoanthropus Dawsoni. "With absolute certainty," says Hugues Obermaier, "we can only say that man of the Quaternary period differed in no essential respect from man of the present day. In no way did he go beyond the limits of variation of the normal human body." ("The Oldest Remains of the Human Body, etc.," Vienna, 1905.) The so-called *Homo primigenius*, therefore, is not a distinct species of human being, but merely an ancient race that is, at most, a distinct variety or subspecies of man. In spite of tireless searching, no traces of a bestial, irrational man have been discovered. Indeed, man whom nature has left naked, defenseless, unarmed with natural weapons, and deficient in instinct, has no other resource than his reason and could never have survived without it. To imagine primitive man in a

condition analogous to that of the idiot is preposterous. "For other animals," says St. Thomas of Aquin, "nature has prepared food, garments of fur, means of defense, such as teeth, horns, and hoofs, or at least swiftness in flight. But man is so constituted that, none of these things having been prepared for him by nature, reason is given him in their stead, reason by which through his handiwork he is enabled to prepare all these things. . . . Moreover, in other animals there is inborn a certain natural economy respecting those things which are useful or hurtful, as the lamb by nature knows the wolf to be its enemy. Some animals also by natural instinct are aware of the medicinal properties of herbs and of other things which are necessary for life. Man, however, has a natural knowledge of these things which are necessary for life only in general, as being able to arrive at the knowledge of the particular necessities of human life by way of inference from general principles." ("De regim. princ.," l. I, c. I.) As a matter of fact, man is never found apart from evidences of his intelligence. The Neanderthaloid race, with their solemn burials and implements of bone and stone, exemplify this truth no less than the palæolithic artists of the Cave of Altamira.

§ 5. The Edict of the American Association

In the Cincinnati meeting (1923-1924) of the American Association for the Advancement of Science, a number of resolutions were passed regarding the subject of evolution. True, the session in which these resolutions were passed was but sparsely attended, and packed, for the most part, with the ultra-partisans of transformism. Nevertheless, it is to be regretted that the dignity of this eminent and distinguished body was so unfittingly compromised by the fulmination of rhetorical anathemas against W. J. Bryan and his Round Head adherents. Among the resolutions, of which we have spoken, the following dictatorial proclamation occurs: *"The evidences in favor of the evolution of man are sufficient to convince every scientist in the world."*

This authoritative decree is both rash and intolerant. The resolution-committee of the American Association is by no means infallible, and, in the absence of infallibility, no group of men should be so unmindful of their own limitations as to strive to make their subjective views binding upon others. Scientific questions are not settled by authority, but exclusively by means of irresistible evidence, which is certainly absent in the present case. Moreover, the declaration in question is untrue; for many of the foremost palæontologists and anthropologists of the day confess their complete ignorance, as scientists, with respect to the origin of man.

Dr. Clark Wissler, for example, who is the Curator-in-Chief of the Anthropological section of the American Museum of Natural History in New York City, made, in the course of an interview published in the *New York American* of April 2, 1918, the following statement: "Man, like the horse or elephant, just happened anyhow, so far as has been discovered yet. As far as science has discovered, there always was a man—some not so developed, but still human beings in all their functions, much as we are to-day." Asked by the reporter, whether this did not favor the idea of an abrupt, unheralded appearance of man on earth, Doctor Wissler replied: "Man came out of a blue sky as far as we have been able to delve back." Fearing lest the reporter might have sensationalized his words, the writer took occasion to question the learned anthropologist on the subject during the Pan Pacific Conference held at Honolulu, Hawaii (Aug. 2-20, 1920). His answer was that the foregoing citations were substantially correct.

The same verdict is given by the great palæontologist, Prof. W. Branco, Director of the Institute of Geology and Palæontology at the University of Berlin. In his discourse on "Fossil Man" delivered August 16, 1901, before the Fifth International Zoölogical Congress at Berlin, Branco said, with reference to the origin of man: "Palæontology tells us nothing on the subject—it knows no ancestors of man." The well-

known palæontologist Karl A. von Zittel reached the same conclusion. He says somewhere (probably in his "Grundzüge der Paläontologie"): "Such material as this (the discovered remains of fossil men) throws no light upon the question of race and descent. All the human bones of determinable age that have come down to us from the European Diluvium, as well as all the skulls discovered in caves, are identified by their size, shape, and capacity as belonging to *Homo sapiens,* and are fine specimens of their kind. They do not by any means fill up the gap between man and the ape." Joseph Le Conte repeats the identical refrain. In the revised Fairchild edition (1903) of his "Elements of Geology" we read: "The earliest men yet found are in no sense connecting links between man and ape. They are distinctly human." (Ch. VI, p. 638.) Replying to Haeckel, who in his "Welträtsel" proclaims man's descent from pithecoid primates to be *an historical fact,* J. Reinke, the biologist of Kiel, declares: "We are merely having dust thrown in our eyes when we read in a widely circulated book by Ernst Haeckel the following words: 'That man is immediately descended from apes, and more remotely from a long line of lower vertebrates, remains established as an indubitable historic fact, fraught with important consequences.' It is absurd to speak of anything as a fact when experience lends it no support." ("Haeckel's Monism and Its Supporters," Leipzig, 1907, p. 6.) The sum-total, in fact, of scientific knowledge concerning the origin of the human body is contained in the saying of the geologist, Sir Wm. Dawson, President of McGill University: "I know nothing about the origin of man, except what I am told in the Scripture—that God created him. I do not know anything more than that, and I do not know of anyone who does."

In view of this uncertainty and ignorance regarding the origin of the human body, it is extremely unethical to strive to impose the theory of man's bestial origin by the sheer weight of scientific authority and prestige. Conscientious scientists would never venture to abuse in such a fashion the

confidence which the people at large place in their assurances. Hence those who respect their honor and dignity as scientists should refrain from dogmatizing on the undemonstrated animal origin of man, however much they may personally fancy this theory. "We cannot teach," says Virchow, "nor can we regard as one of the results of scientific research, the doctrine that man is descended from the ape or from any other animal." ("The Liberty of Science," p. 30, et seq.) And Professor Reinke of Kiel concludes: "The only statement consistent with her dignity, that Science can make, is to say that she knows nothing about the origin of man." (*Der Türmer,* V, Oct., 1902, Part I, p. 13.)

A slave, we are told (Tertul., *Apolog.* 33), rode in the triumphal chariot of the Roman conqueror, to whisper ever and anon in his ear: *Hominem memento te!*—"Remember that thou art a man!" It is unfortunate that no similar warning is sounded when the tone of scientific individuals or organizations threatens to become unduly imperious and intolerant. This tendency, however, to forget limitations and to usurp the prerogative of infallibility is sometimes rebuked by other reminders. The writer recalls an instance, which happened in connection with the Pan Pacific Conference at Honolulu during the August of 1920.

The Conference was attended by illustrious scientists from every land bordering upon the Pacific. After the preliminary sessions, the delegates paid a visit to the famous volcano of Kilauea. Doctor T. A. Jaggar, Jr., vulcanologist and Director of the United States Observatory at Kilauea, acted as guide, the writer himself being one of the party. In the course of our tour of inspection, we came to the extinct volcano of Kenakakoe. There a number of volcanic bombs, some shattered and some intact, were pointed out to us. For the benefit of readers, who may not know, I may state that a volcanic bomb originates as a fragment of foreign material, *e.g.* a stone, which, falling into a volcano, becomes coated with an external shell of lava. In addition to the bombs,

certain holes in the soil were shown to us, which Doctor Jaggar, evidently under the influence of military imagery suggested by the then recent European War, described as "shell-craters" dug by the aforesaid volcanic bombs.

Doctor Jaggar accounted for the bombs and craters by a very ingenious theory. In 1790, he said, the year in which Kamehameha I was contending with Keoua for the mastery of the large island of Hawaii, the only explosive eruption of Kilauea known to history occurred, and it was during this eruption (which destroyed part of Keoua's army) that the bombs found at Kenakakoe were ejected from the above-mentioned volcano. It was then, we were informed, that these bombs hurtling through the air in giant trajectories from Kilauea struck the ground and scooped out the "shell-craters" at Kenakakoe. Some of them, it appeared, did not remain in the craters, but rebounded to strike again on the rocks beyond. Of the latter, part were shattered, while others withstood the force of the second impact. The whole party was much impressed by the grandeur of this vivid description, and some of the scientists were at great pains to photograph the craters as awe-inspiring vestiges of the mighty bombardment wrought in times past by Nature's volcanic artillery.

When I returned to Hilo, I happened to mention to Brother Matthias Newell some misgivings which I had felt concerning the size and appearance of the so-called "shell-craters." Brother Newell, a member of the Marist Congregation and quite a scientist in his way, is famous in the Islands as the discoverer of a fungus, by which the Japanese Beetle, a local pest, has been largely exterminated. For several years, prior to the advent of Doctor Jaggar and the United States Observatory, he had studied extensively the famous volcano on the slopes of Mauna Loa. On hearing my narrative of the foregoing incident, Brother Newell was curious to know the exact locality, and burst into a hearty laugh as soon as I mentioned Kenakakoe. He himself, he told me, in company with Brother

Henry, had frequently dug for bombs at Kenakakoe. When successful in their quest, the two were wont to carry the volcanic bomb to the rocks, and to break it open for the purpose of examining the inner core. Some of the bombs, however, escaped this fate through being too resistent to the hammer. The holes, needless to say, were not "shell-craters" scooped by volcanic bombs, but ordinary excavations dug by prosaic spades. Such was the simple basis of fact upon which the elaborate superstructure of Jaggar's theory had been reared! Though Jaggar was, in a sense, entirely blameless, his theory was pure fiction from start to finish. No scientist present, however, took exception to it. On the contrary, all of them appeared perfectly satisfied with his pseudoscientific explanation.

If the foregoing incident conveys any lesson, it is this, that neither singly nor collectively are scientists exempt from error, especially when they deal with a remote past, which no one has observed. The attempt to reconstruct the past by means of inference alone produces, not history, but romance. Doctor McGregor's genealogy of Man displayed in the American Museum is quite as much the fruit of imagination as Jaggar's Kilauean fantasy. The sham pedigree bears like witness to the ingenuity of the human mind, but, if anyone is tempted by its false show of science to take it seriously, let him think of the bombs of Kenakakoe.

AFTERWORD

With the close of the nineteenth century the hour hand of biological science had completed another revolution. One after another, the classic systems of evolution had passed into the discard, as its remorseless progress registered their doom. The last of these systems, De-Vriesianism, enjoyed a meteoric vogue in the first years of the present century, but it, too, has gone into eclipse with the rise of rediscovered Mendelism. Notwithstanding all these reverses, however, the evolutionary theory still continues to number a host of steadfast adherents.

Some of its partisans uphold it upon antiquated grounds. Culturally speaking, such men still live in the days of Darwin, and fail to realize that much water has passed under the bridge since then. It has other protagonists, however, who are thoroughly conversant with modern data, and fully aware, in consequence, of the inadequacy of all existent formulations of the evolutional hypothesis. Minds of the latter type are proof, apparently, against any sort of disillusionment, and it is manifest that their attitude is determined by some consideration other than the actual results of research.

This other consideration is monistic metaphysics. In defect of factual confirmation, evolution is demonstrated aprioristically from the principle of the minimum. The scope of this methodological principle is to simplify or unify causation by dispensing with all that is superfluous in the way of explanation. In olden days, it went by the name of Occam's Razor and was worded thus: *Entia non sunt multiplicanda praeter necessitatem*—"Things are not to be multiplied without necessity." Evolution meets the requirements of this principle. It simplifies the problem of organic origins by reducing the number of ancestors to a minimum. Therefore, argues the evolutionist, evolution must be true.

As an empirical rule, the principle of the minimum is, no doubt, essential to the scientific method. To erect it into a metaphysical axiom, however, is preposterous; for *simple* explanations are not necessarily *true* explanations. In the rôle of aprioristic metaphysics, the principle of continuity is destructive, and tends to plane down everything to the dead level of materialistic monism. For those who transcendentalize it, it becomes the principle "that everything is 'nothing but' something else, probably inferior to it." (Santayana.) To assert continuity, they are driven to deny, or, at least, to leave unexplained and inexplicable, the obvious novelty that emerges at each higher level of the cosmic scale. And thus it comes to pass that intelligence is pronounced to be nothing but sense, and sense to be nothing but physiology, and physiology to be nothing but chemistry, and chemistry to be nothing but mechanics, until this philosophical nihilism weeps at last for want of further opportunities of devastation. Its exponents have an intense horror for abrupt transitions, and resent the discovery of anything that defies resolution into terms of mass and motion.

Evolution smooths the path for monism of this type by transforming nature's staircase into an inclined plane of imperceptible ascent. Hence Dewey refers to evolution as a "clinching proof" of the continuity hypothecated by the monist. For the latter, there is no hierarchy of values, and all essential distinctions are abolished; for him nothing is unique and everything is equally important. He affirms the democracy of facts and is blind to all perspective in nature. He is, in short, the enemy of all beauty, all spirituality, all culture, all morality, and all religion. He substitutes neurons for the soul, and enthrones Natural Selection in the place of the Creator. He sets up, in a word, the ideal of "an animalistic man and a mechanistic universe," and offers us evolution as a demonstration of this "ideal."

Vernon Kellogg objects to our indictment. "The evolutionist," he says, "does not like being called a bad man. He

does not like being posted as an enemy of poetry and faith and religion. He does not like being defined as crassly materialist, a man exclusively of the earth earthy." (*Atlantic Monthly*, April 24, 1924, p. 490.) Apart from their object, the likes or dislikes of an evolutionist are a matter of indifference. What we want to know is whether his dislike is merely for the names, or whether it extends to the reality denoted by these names. Human nature has a weakness for euphemisms. Men may "want the game without the name," particularly when, deservedly or undeservedly, the name happens to have an offensive connotation.

There are, no doubt, evolutionists who mingle enough dualism with their philosophy to mitigate the most objectionable aspects of its basic monism. In so doing, however, they are governed by considerations that are wholly extraneous to evolutionary thought. Indeed, if we take Kellogg's words at their face value (that is, in a sense which he would probably disclaim), it is in spite of his philosophy that the evolutionist is a spiritualist. "And just as religion and cheating," reasons Kellogg, "can apparently be compassed in one man, so can one man be both evolutionist and idealist." (*Loc. cit.*, p. 490.) If this comparison holds true, the evolutionist can be an idealist only to the extent that he is inconsistent or hypocritical, since under no other supposition could piety and crime coëxist in one and the same person.

Be that as it may, the majority of evolutionists are avowed mechanists and materialists, in all that concerns the explanation of natural phenomena. "That there may be God who has put his Spirit into men" (Kellogg, *ibid.*, p. 491), they are condescendingly willing to concede. And small credit to them for this; for who can *disprove* the existence of God, or the spirituality of the human soul? Nevertheless, it is impossible, they maintain, to be *certain* on these subjects. Natural science is in their eyes the only form of human knowledge that has any objective validity. Proofs of human spirituality they denounce as *metaphysical,* and metaphysics is for them synony-

mous with "such stuff as dreams are made of," unworthy to be mentioned in the same breath with physical science—"Es gibt für uns kein anderes Erkennen als das mechanische, . . . Nur mechanisch begreifen ist Wissenschaft." (Du Bois-Reymond.)

In practice, therefore, if not in theory, the tendency of evolution has been to unspiritualize and dereligionize the philosophy of its adherents, a tendency which is strikingly exemplified in one of its greatest exponents, Charles Darwin himself. The English naturalist began his scientific career as a theist and a spiritualist. He ended it as an agnostic and a materialist. His evolutionary philosophy was, by his own confession, responsible for the transformation. "When thus reflecting," he says, "I feel compelled to look to a first cause having an intelligent mind in some degree analogous to that of man, and I deserve to be called a Theist. This conclusion was strong in my mind about the time, as far as I remember, when I wrote the 'Origin of Species'; and it is since that time that it has very gradually, with many fluctuations, become weaker. But then arises the doubt, can the mind of man, which has, as I fully believe, been developed from a mind as low as that possessed by the lowest animals, be trusted when it draws such grand conclusions? I can not pretend to throw the least light on such abstruse problems. The mystery of the beginning of all things is insoluble by us; and I, for one, must be content to remain an Agnostic." ("The Life and Letters of Charles Darwin," edited by Francis Darwin, 1887, vol. I, p. 282.)

Darwin likewise exemplifies in his own person the destructive influence exercised upon the æsthetic sense by exclusive adherence to the monistic viewpoint. Having alluded in his autobiography to his former predilection for poetry, music, and the beauties of nature, he continues as follows: "But now for many years I cannot endure to read a line of poetry: I have tried lately to read Shakespeare, and found that it nauseated me. I have also lost my taste for pictures and music. . . . I

retain some taste for fine scenery, but it does not cause me the exquisite delight which it formerly did. . . . My mind seems to have become a kind of machine for grinding general laws out of large collections of facts; . . . if I had to live my life again, I would have made it a rule to read some poetry and listen to some music at least every week; for perhaps the parts of my brain now atrophied would have been kept alive through use. The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character by enfeebling the emotional part of our nature." (*Op. cit.*, vol. I, pp. 81, 82.)

Evolution, we repeat, has brought us materialistic monism, in whose barren soil nor faith, nor idealism, nor morality, nor poesy, nor art, nor any of the finer things of life can thrive. To its dystelic and atomistic view, Nature has ceased to be the vicar of God, and material things are no longer sacramental symbols of eternal verities. It denies all design in Nature, and dismembers all beauty into meaningless fragments. It is so deeply engrossed in the contemplation of parts, that it has forgotten that there is any such thing as a whole. The rose and the bird-of-paradise are not ineffable messages from God to man; they are but accidental aggregates of colloidal molecules fortuitously assembled in the perpetual, yet aimless, flux of evolving matter.

From the standpoint of the moral and sociological consequences, however, the gravest count against evolution is the seeming support which this theory has given to the monistic conception of an animalistic man. Darwin's doctrine on the bestial origin of man brought no other gain to natural science than the addition of one more unverified and unverifiable hypothesis to its already extensive stock of unfounded speculations. It did, however, work irreparable harm to millions of unlearned and credulous persons, whose childlike confidence the unscrupulous expounders of this doctrine have not hesitated to abuse. The exaggerations and misrepresentations of the latter met with an all too ready credence on the part of those

who were not competent to discriminate between theory and fact. The sequel has been a wholesale abandonment of religious and moral convictions, which has ruined the lives and blighted the happiness of countless victims.

Has it been worth while, we may well ask of the propounders of this theory, to sacrifice so much in exchange for so little? The solid gain to natural science has been negligible, but the consequences of the blow unfairly dealt to morals and religion are incalculable and beyond the possibility of repair. "Morals and Religion," says Newman, "are not represented to the intelligence of the world by intimations and notices strong and obvious such as those which are the foundation of physical science. . . . Instead of being obtruded on our notice, so that we cannot possibly overlook them, they are the dictates either of Conscience or of Faith. They are faint shadows and tracings, certain indeed, but delicate, fragile, and almost evanescent, which the mind recognizes at one time, not at another, discerns when it is calm, loses when it is in agitation. The reflection of sky and mountains in the lake is proof that sky and mountains are around it, but the twilight or the mist or the sudden thunderstorm hurries away the beautiful image, which leaves behind it no memorial of what it was. . . . How easily can we be talked out of our clearest views of duty; how does this or that moral precept crumble into nothing when we rudely handle it! How does the fear of sin pass off from us, as quickly as the glow of modesty dies away from the countenance! and then we say 'It is all superstition.' However, after a time, we look around, and then to our surprise we see, as before, the same law of duty, the same moral precepts, the same protest against sin, appearing over against us, in their old places, as if they had never been brushed away, like the Divine handwriting upon the wall at the banquet." ("Idea of a University," pp. 513-515.)

Had evolutionary enthusiasts adhered more strictly to the facts, had they proceeded in the spirit of scientific caution, had they shown, in fact, even so much as a common regard

for the simple truth, the "progress of science" would not have been achieved at the expense of morals and religion. As it is, this so-called progress has left behind a wake of destruction in the shape of undermined convictions, blasted lives, crimes, misery, despair, and suicide. It has, in short, contributed largely to the present sinister and undeserved triumph of Materialism, Agnosticism, and Pessimism, which John Talbot Smith has so fittingly characterized as the three D's of dirt, doubt, and despair. A little less sensationalism, a little more conscientiousness, a little more of that admirable quality, scientific caution, and the concord of faith and reason would have become a truism instead of a problem. But such regrets are vain. The evil effects are here to stay, and nothing can undo the past.

If man is but a higher kind of brute, if he has no unique, immortal principle within him, if his free will is an illusion, if his conduct is the necessary resultant of chemical reactions occurring in his protoplasm, if he is nothing more than an automaton of flesh, a mere decaying organism which is the sport of all the blind physical forces and stimuli playing upon it, if he has no prospect of a future life of retribution, if he is unaccountable to any higher authority, Divine or human, then morality ceases to have a meaning, right and wrong lose their significance, virtue and vice are all the same. The constancy of the martyr and the patriotism of the fallen soldier become unintelligible folly, while a heartless and infamous sensualism preying vulturelike upon the carrion of human misery and corruption is to be reckoned the highest expression of wisdom and efficiency. The grandest ideals that have inspired enthusiasm and devotion in human breasts are but idle dreams and worthless delusions. From a world which accepts this degraded view of human nature all heroism and chivalry must vanish utterly; for it will recognize no loftier incentives to action than pleasure and love of self.

Such doctrines, too, are essentially antisocial. They destroy the very foundation of altruism. To seek immortality in the

effects of one's unselfish deeds becomes ridiculous. For what assurance can we have that the fruits of our sacrifice will be acceptable to a progressive posterity, or what difference will our self-denial make, when the whole human species shall have become extinct on the desolate surface of a dying world? Without an adequate motivation for altruism, however, the existence of society becomes impossible, since self-interest is not a feasible substitute. To urge the observance of social laws on the ground that they protect person, life, and property, will hardly appeal to men who have no possessions to be protected nor a comfortable life to be prolonged. Yet the major portion of mankind are in this category. For such the laws can mean nothing more than artificial corruptions, of the natural and primitive order of things introduced for the special benefit of the rich and powerful.

Under circumstances of this sort, no plea avails to silence the heralds of revolt. If there is no future life for the righting of present injustices, then naught remains but to terminate the prosperity of the wicked here and now. If there is no heaven for man beyond the grave, then it behooves everyone to get all the enjoyment he can out of the present life. It is high time, therefore, that this earthly heaven of mankind should cease to be monopolized by a few coupon-holding capitalists and become, instead, the property of the expropriated proletariat. Anarchy and Socialism are the consequences which the logic of the situation inexorably portends. The starving swine must hurl their bloated brethren from the trough that the latter have heretofore reserved for themselves. The sequel, of course, can be none other than the complete disintegration of civilization and its ultimate disappearance in a hideous vortex of carnage, rapine, and barbarity.

Nor is this prognosis based on pure conjecture. In proportion as these pernicious doctrines have gained ground, modern society has become infected with the virus of animalism, egoism, and perfidy; expediency has been substituted for honor; and purity has been replaced by prophylaxis.

One could not, of course, expect to see a universal and thoroughgoing application of these principles in the concrete. The materialistic view of human nature is horribly unnatural, and, in practice, would be quite unbearable. Natural human goodness and even the mere instinct of self-preservation militate against a reduction to the concrete of this inhuman conception, and these tend, in real life, to mitigate the evil effects of its acceptance. Nevertheless, the actual consequences resulting from the spread of evolutionary principles are so conspicuous and appalling as to leave no doubt whatever of the deadly nature of this philosophy.

Marxian Socialism has been called "scientific" for no other reason than that it is based upon materialistic evolution, and this scientific socialism has brought upon modern Russia a reign of terror, which eclipses that of France in the bloodiest days of the Revolution. Eleanor Marx, it will be remembered, after falling a victim to her father's teachings regarding "free love," committed suicide. The same confession of failure has been made by two recent editors of the socialist *Appeal to Reason* (J. W. Wayland and J. O. Welday), both of whom committed suicide. These are but a few of the many instances that might be cited to show that the life philosophy inculcated by materialistic evolution is so intolerably unnatural and revolting that neither society nor the individual can survive within the lethal shadow of its baleful influence.

But may not the extreme materialism and pessimism of this view be peculiar to the sordid and joyless outlook of the social malcontent? Does not evolutionary thought conduce to something finer and more hopeful in the case of the progressive and optimistic liberal? Vain hope! We cannot console ourselves with any delusions on this score. Liberalism proclaims the emancipation of humanity from all authority, and the rejection of a future life of retribution is the indispensable premise of the doctrine that makes man a law unto himself. Hence, wherever Liberalism controls the tongues of educators, the human soul becomes a myth, religion a superstition, and

immortality an anodyne for mental weaklings. Strong-minded truth-seekers are advised to abandon these irrational beliefs, and to adopt the "New Religion," which dispenses once for all with God and the hereafter. "The new religion," says Charles Eliot, ex-President of Harvard, "will not attempt to reconcile people to present ills by the promise of future compensation. I believe that the advent of just freedom has been delayed for centuries by such promises. Prevention will be the watchword of the new religion, and a skillful surgeon will be one of its ministers. It cannot supply consolation as offered by old religions, but it will reduce the need of consolation." ("The New Religion.")

Again, it may be objected that evolutionists, for all their agnosticism and materialism, frequently put Christians to shame by their irreproachably upright and moral lives. That they sometimes succeed in doing this cannot be gainsaid. But they do so because they borrow their moral standards from Christianity, and do not follow the logical consequences of their own principles. Their morality, therefore, is parasitic, as Balfour has wisely observed, and it will soon die out when the social environment shall have been sufficiently de-Christianized. "Eat, drink, and be merry, for tomorrow we die," is their proper philosophy of life, only they have not the courage of their convictions. For the rest, their philosophical convictions have nothing in common with the moral standards which they actually observe. In fact, not only does the monism of evolutionary science fail to motivate the Christian code of morals, but it is radically and irreconcilably opposed to all that Christianity stands for. Hartmann, a modern philosopher, notes with grim satisfaction the clash of the two viewpoints, and predicts (with what, perhaps, is premature assurance) the ultimate triumph of "modern progress." "Many there are," he tells us, "who speak and write of the struggle of civilization, but few there are who realize that this struggle is the last desperate stand of the Christian ideal before its final disappearance from the world, and that modern

civilization is prepared to resort to any means rather than relinquish those things, which it has won at the cost of such great toil. For modern civilization and Christianity are antagonistic to each other, and it is therefore inevitable that one give place to the other. Modern progress can acknowledge no God save one immanent to the world and opposed to the transcendent God of Christian revelation, nor other morality save only that true kind whose source is the human will determining itself by itself and becoming a law unto itself." ("Religion de l'avenir.")

The World War has done much to dampen the ardor of those who looked forward with enthusiasm to the millennium of a purely scientific religion. In this spectacular lesson they have learned that science can destroy as well as build. They have come to see that biology, physics, and chemistry are morally colorless, and that we must go outside the realm of natural science when we are in quest of that which can give meaning to our lives and noble inspiration to our conduct. When science supersedes religion, the result is always disillusionment following in the wreck-strewn wake of moral and physical disaster.

> Grave little manikins digging in the slime
> Intent upon the old game of 'Once-upon-a-time.'
> Other little manikins engaged with things-to-come,
> Building up the sand-heap called Millennium.
>
> (*Theodore MacManus*)

Recently, the chancellor of a great university has seen fit publicly to disclaim, in the name of his institution, all responsibility for a crime committed by two members of the student body. The young men involved in this affair had performed an experimental murder. The experimenters, it would seem, were unable to discriminate between man and beast. They had been taught by their professors that scientific psychology dispenses with the soul, and that the difference

between men and brutes is one of degree only, and not of kind. Even that negligible distinction, they were told, had been bridged by evolution. In the sequel, the young men failed, apparently, to see why vivisection, which was right in the case of animals, should be wrong in the case of human beings. Their astounding obtuseness on this particular point was, of course, exceedingly regrettable and hard to understand. Yet, somehow, one cannot help thinking but that their education was largely responsible for it.

In the startling crime of these students, modern educators will find much food for serious thought. It should give pause to those, especially, who have been overzealous in popularizing the Darwinian conception of human nature. Let men of this type reflect upon what slender grounds their dogmatism rests, and let them then weigh well the gravity of the responsibility, which they incur. Tuccimei summarizes for them, in the following terms, the nature and extent of their accountability:

"This perverse determination to place man and brutes in the same category, interests me not so much from the scriptural standpoint as for reasons moral and social. Science, as the more moderate of our adversaries have told us often enough, does not assail religion, but proceeds on its way regardless of the consequences. And the consequences we see only too plainly, now that the evolutionary philosophy has invaded every branch of knowledge and walk of life, and has seeped down among the ignorant and turbulent masses. These consequences are known as socialism and anarchy. The protagonists of the new philosophy strove to repudiate them at first: but now many of their number have laid aside even this pretense. Socialistic doctrines are based exclusively upon our assumed kinship with the brutes, and the leaders of militant socialism have inscribed on the frontispieces of their books the chain fatally logical and terribly true of three names, Darwin, Spencer, Marx.

"In truth, our common origin with the brutes being taken for granted, why should we not enjoy in common with them

the right to gratify every instinct? Social inequalities are the product of laws and conventionalities willed by the rich and powerful. In the natural and primitive state of things they did not exist; why not proceed then to a general leveling of the existing social order?

"Such an origin of the human race being assumed, the existence of the soul and a future life becomes a myth invented by the priests of the various religions. With this inconvenient restraint removed, there remains no alternative save to aspire to the acquisition of all the pleasures of life; and for him who lacks the wherewithal to procure them for himself there remains no other recourse than to seek them by means of violence or strategy. Hence anarchy. In this supposition, morality no longer possesses that sole, true, and efficacious sanction which religion alone can furnish; it amounts to nothing more than the resultant of the evolution of the individual's perfections and their coördination to the well-being of his race and of society. But if, by reason of retarded evolution, the social instincts have not progressed to the point of repressing the individual or egoistic instincts, what guilt will there be in the delinquent who lapses into the most atrocious crimes? Hence free will is another myth that positive psychology and the science of moral statistics have already been at pains to explode.

"And behold the suffering, the unfortunate, and the dying deprived of their sole consolation, the last hope which faith held out to them, and society reduced to an inferno of desperadoes and suicides! I could go on showing in this way, to what a pass the evolutionistic theories bring society and the individual." ("La teoria dell' evoluzione e le sue applicazioni," p. 46.)

GLOSSARY

Abiogenesis: The discredited hypothesis that life may originate spontaneously in lifeless matter, *i.e.*, apart from the influence of living matter.

Adaptation: (1) The reciprocal aptitude of organism and environment for each other; (2) a structure, modification of structure, or behavioristic response enabling the organism to solve a special problem imposed by the environment; (3) the process by which the organism's adjustment to the environment is brought about.

Allelomorphs: Genes located opposite each other on homologous chromosomes and representing contrasting characters; they are separated during meiosis according to the Mendelian law of segregation, e.g. the genes for red and white in Four o'clocks which when united give rise to pink, and when segregated, to red and white flowers respectively, are allelomorphs of each other.

Alluvial: Pertaining to the Alluvium, which consists of fresh-water deposits of the Pleistocene and Recent series, to be distinguished from the Diluvium which consists of older Pleistocene formations.

Amino-acids: The chemical building-stones of the proteins —organic acids containing one or more amino-groups (—NH_2) in place of hydrogen, *e.g.*, amino-acetic acid, $CH_2{\cdot}NH_2{\cdot}COOH$.

Amnion: A membranous bag which encloses the embyro in higher vertebrates. The lower vertebrates, namely, fishes and amphibia, have no amnion and are termed "anamniotic." The reptiles, birds, and mammals which possess it are termed amniotic vertebrates.

Amphioxus: The most simply organized animal having a dorsal notochord. It is classified among the Acrania in

contradistinction to the craniate Chordates which make up the bulk of the vertebrates.

Angiosperms: The higher plants, which have their seeds enclosed in seed-vessels.

Anthropoid Apes: Apes of the family SIMIIDÆ, which approach man most closely in their organization, namely, the chimpanzee, the gorilla, the gibbon, and orang-utan.

Antibody: Chemical substances produced in the blood in reaction to the injection of antigens or toxic substances and capable of counteracting or neutralizing said substance. Such antibodies are specific for determinate antigens.

Antigen: Any substance that causes the production of special antibodies in the blood of susceptible animals, after one or several injections.

Arthropods: The phylum of exoskeletal invertebrates comprising crustaceans, arachnida, insects, etc.

Atavism: The resemblance to an ancestor more distant than the parents.

Automatism: A spontaneous action, not in response to recognizable stimuli.

Basichromatin: That portion of a cell's nuclear network which contains nuclein and is deeply stained by basic dyes.

Biparental: Derived from two progenitors, *i.e.*, a father and mother.

Brachiopods: Invertebrate animals bearing a superficial resemblance to bivalve molluscs, but belonging to a totally different group—lamp shells.

Cabrian: The "oldest" system of the Palæozoic group of fossiliferous rocks.

Carbohydrates: The sugars, starches, etc.,—polyhydric alcohols with aldehydic or ketonic groups, and acetals of same, etc.

Catalyst: A substance which accelerates a chemical reaction without permanently participating in it, being left over unchanged at the end of the process.

Centriole: The centrioles or central bodies are the foci of

mitotic division in animal cells, as well as the source of the kinetic elements developed by such cells. They are minute bodies usually located within a larger sphere known as the centrosome or centrosphere. They do not occur in the cells of the higher plants.

Cephalopods: A class of molluscs in which the foot is developed into a headlike structure with eyes and a circle of arms, *e.g.*, the octopus, the cuttlefish, the squid, and the nautilus.

Ceratites: A genus of extinct cephalopods having a coiled shell and crooked sutures.

Character: An external feature or sensible property of an organism. It is the joint product of germinal factors (genes) and environmental influences.

Chlorophyll: The green pigment formed in the chloroplasts (green plastids) of plant cells. It is a diester of phytyl and methyl alcohols with the tribasic acid, chlorophyllin, one of whose carboxyls is esterified with methyl alcohol, a second with phytol, while the third is otherwise engaged. Chlorophyllin is a tribasic acid consisting of the chlorophyllic chromogen group (containing magnesium) joined to three carboxyl groups.

Chondriosomes: Cytoplasmic granules rodlike, threadlike, or spherical in form, which often appear to divide on the mitotic spindle, and are therefore credited with the power of independent growth and division. The chondriosomes of embryonic tissues are thought to be the original sources of the plastids, the fibrillæ, and certain metaplastic granules.

Chordates: The phylum of animals whose primary axial skeleton consists temporarily or permanently of a notochord.

Chromatin: Same as basichromatin.

Chromosomes: The short threads or rodlike bodies into which the basichromatin of the cell-nucleus is aggregated during mitosis—each chromosome is segmented into granules called chromomeres—in its submicroscopic structure it consists of chain or linear series of genes (hereditary factors) representing characters linked together in

heredity, each single chromosome being termed, on this account, a "linkage-group" by geneticists.

Ciliate: A protozoan whose motor-apparatus consists of cilia, *i.e.*, hairlike protoplasmic projections capable of rapid and coördinated vibratile movement.

Cloaca: A common passageway through which the intestine, kidneys, and sex organs discharge their products,—it occurs in certain fishes, in amphibia, reptiles, and birds, and in a few mammals.

Coccyx: Lower extremity of the vertebral column in man.

Colloids: Insoluble gumlike substances, which will not diffuse through organic membranes.

Commensalism: The harmonious cohabitation of two organisms belonging to different species, where the relation is not necessarily beneficial nor necessarily harmful to either.

Crossover: The exchange or reciprocal transfer of whole blocks of genes from one homologous chromosome to the other, which sometimes occurs in synapsis, probably at the strepsinema-stage.

Crystalloids: Soluble substances, which usually form crystals and readily diffuse through organic membranes.

Cyst: A protective envelope formed around an organism during period of rest.

Cytode: The non-nucleated cell hypothecated by Haeckel.

Cyptoplasm: The cell-body or extranuclear protoplasm of a cell.

Endomixis: A process of nuclear reorganization among the protozoa, which does not require the coöperation of two cells as in conjugation (amphimixis).

Endoskeleton: An internal living skeleton providing support and protection (as well as organs of movement, in the bone-levers to which the muscles are attached)—it is characteristic of the vertebrates.

Enzymes: Organic catalysts, *i.e.*, complex chemical substances formed by organisms and serving to accelerate chemical processes taking place in said organisms, *e.g.*,

the digestive enzymes, which accelerate the hydrolysis of starches, fats, and proteins.

Epigenesis: Development of the embryo by differentiation of previously undifferentiated protoplasm.

Fats: Esters of the higher fatty or organic acids (such as stearic, palmitic, and oleic) esterified with the trihydric alcohol glycerine (glycerol).

Gamete: A reproductive cell specialized for syngamy, *i.e.*, for union with a complementary germ cell, their union giving rise to a synthetic cell known as a zygote.

Ganglion: An aggregate of nerve-cells consisting mainly of neural cell-bodies together with supporting cells.

Ganoids: Fishes covered with enameled bony scales, and now, for the most part, extinct.

Gene: A factor or infinitesimal element in a nuclear thread or chromosome, the latter being a linear aggregate of such factors, each having definite specificity and manifesting itself in the external character which develops from it.

Genotype: The total assemblage of germinal factors transmitted by a given species of organism, that is, the complete complex of genes synthesized in the zygote and perpetuated by equation-divisions in the somatic cells. Hence the basic germinal or hereditary constitution of an organism or group of organisms.

Germ Cells: Cells specialized for reproduction as contrasted with other vital functions, *e.g.*, spores and gametes.

Germ-plasm: The material basis of inheritance.

Glacial Epoch: After the close of the Tertiary period, Europe and North America are said to have been covered with vast ice sheets known as continental glaciers (the result of great climatic changes in the Northern hemisphere). As the weather varied these ice sheets advanced and retreated, the retreats corresponding to the so-called Interglacial intervals. Four Glacial and three Interglacial stages are distinguished, and it was during the Second and Third of these Interglacial stages that Palæolithic Man is alleged to have entered Europe.

Golgi Bodies: A cytoplasmic apparatus consisting, in its localized form, of a network, and, in its dispersed form, of scattered granules. It appears to divide on the mitotic spindle, and seems to have some important function connected with secretion.

Habitat: The locality in which a given animal or plant normally lives.

Hallux: The great toe, opposable in the ape, but not in man.

Heredity: "The appearance in offspring of characters whose differential causes are in the germ cells" (Conklin).

Heterozygous: Hybrid,—the condition in which the chromosomal genes paired by syngamy in the zygote are unlike.

Homologous Chromosomes: Corresponding chromosomes of the same synaptic pair, being of paternal and maternal origin respectively.

Homozygous: Pure,—the condition in which the chromosomal genes paired in the zygote by syngamy are alike.

Hormone: An internal secretion elaborated in the endocrine or ductless glands and diffused in the blood stream for the purpose of influencing the activities or metabolism of parts of the organism at a distance from the source of the hormone, *e.g.,* secretin, gastrin, adrenalin, etc.

Hydrotheca: The cuplike extension of the perisarc (skeletal sheath) surrounding the hypostome (oral cone) and tentacles of certain polyps.

Hyloblatic: Resembling the gibbon.

Lemurs: Four-handed animals allied to the Insectivora, with curved nostrils and a claw instead of a nail on the first finger of the rear hands.

Lethals: A genetical term for hereditary factors (genes) which cause the death of the gametes or the zygotes that contain them. In the case of zygotes, death results from the homozygous, but not from the heterzygous, condition.

Linin: Same as oxychromatin.

Litopterna: A suborder of extinct ungulate mammals from the Miocene and Pliocene of South America resembling horses or llamas.

Mammals: Vertebrate animals which suckle their young after birth.

Meiosis: The process whereby the chromosomes of synaptic pairs (in the primary oöcyte or spermatocyte) are separated in such a way that the resulting gametes (eggs, or sperms) receive a haploid (halved) number of unpaired chromosomes, instead of the diploid (double) number of paired chromosomes characteristic of the zygote and the somatic cells of the species.

Metista: Animals and plants normally multicellular and having their cells differentiated into at least two distinct layers or tissues—the Metazoans and Metaphytes.

Mitosis: Typical cell-division, whose mechanism consists of the spindle-fibers, and whose scope is to secure an exactly equal partition of the single components of the nucleus of the dividing cell between the two resultant daughter-cells.

Monism: A system of thought which holds that there is but one substance, either mind (idealistic subjectivism), or matter (objectivistic materialism),—or else a substance that is neither mind nor matter, but is the substantial ground of both. Idealistic monism regards mind as the sole reality and matter as its product. Materialistic monism regards matter as the sole reality and mind as its product.

Neolithic: Pertaining to the Young-Stone Age, that is, to prehistoric man of Post-glacial time. The implements of the latter are of polished stone. The Young-Stone Age is said to have begun about 7,000 years B.C., and to have ended with the Copper Culture about 2,000 B.C. The Bronze Age, which followed it, belongs to history.

Neurone: The nerve-cell with all its processes, consisting, therefore, of the nucleated cell-body, the axone or discharging fiber, and the dentrites or receiving fibers.

Oölites: An English term for the Jurassic, or middle system of the Mesozoic group of fossiliferous rocks.

Ontogeny: The embryological development of the individual.

Opposable: A term applied to the thumb or great toe when they are capable of being placed with their tips opposite to those of the other digits.

Organelle: Literally, a "miniature organ," *i.e.*, one of the living components of a cell as distinguished from the metaplastic or non-living inclusions.

Oxychromatin: That portion of the nuclear network which stains with acidic dyes, the finer nuclear reticulum in which the coarser strands of basichromatin appear to be suspended.

Palæolithic: Belonging to the Old-Stone Age, which corresponds to the latter half of the Glacial or Pleistocene epoch. It is alleged to be the second period of prehistoric man (following the Eolithic) and is characterized by implements of unpolished stone shaped from flint by the chipping off of flakes of the latter substance.

Palæontology: The science of fossil organisms.

Palæozoic: A term applied to the second group of fossiliferous rocks, following the earliest, or Proterozoic, group, and preceding the Mesozoic group. It comprises the Cambrian, Ordovician, Devonian, Silurian, and Carboniferous systems, and its sediments are the first that contain well-preserved fossils.

Parasitism: A condition in which one organism (the parasite) residing in, or upon, another species of organism (the host) lives at its expense, the relation being detrimental to the latter.

Parthenogenesis: The production of offspring from unfertilized eggs.

Phenotype: The sum-total of external characters by whose enumeration an organism is described—the somatic or expressed characters of an organism (or group of organisms) as distinguished from those that are merely potential in the germ cells.

Phylogeny: Developmental history of the race, the hypothetical evolutionary history of the race, in contradistinction to the embryological development of the individual (ontogeny).

Phylum: A term used in classification to denote any primary group of the plant or animal kingdom.

Plantigrade: Walking on the whole sole of the foot, like bears.

Plastids: Permanent organelles or living components of the cellular cytoplasm, *e.g.*, chloroplasts, leucoplasts, etc.

Pleistocene: The lower series of the Quaternary system of fossiliferous rocks. It corresponds to the so-called Glacial epoch, and extends from the close of the Tertiary period (system) to the dawn of the Recent or Historical epoch.

Polar Cell: A synonym for polar body, or policyte. The polar bodies are minute abortive cells given off by the egg undergoing meiosis. Into them are shunted the chromosomes which the egg discards in its process of nuclear reduction (maturation).

Præformation: Theory that the egg contains a complete miniature of the organism into which it develops.

Prehension: Grasping, catching hold.

Progression: Advancing movement, locomotion.

Pro-simiæ: The lemurs as distinguished from genuine apes (Simiæ).

Protista: Animals or plants which are normally unicellular and which when multicellular show no differentiation into tissues—the Protozoans and Protophytes.

Protoplasm: Living matter.

Receptor: An organ specialized to receive stimuli, *e.g.*, a sense-organ.

Sedimentary: A term applied to rocks which originated as sediments deposited under water.

Serum: Watery portion of the blood, the plasma.

Somatic Cells: Vegetative cells not especially set aside by the organism for reproductive purposes, *e.g.*, tissue-cells.

Somite: One of the uniform segments of the longitudinal series into which a metameric organism (such as an earthworm) is partitioned.

Spermatist: An old term applied to one who held that the animal embryo was produced entirely by the male parent.

Spore: A single cell, incapable of syngamy, but capable of giving rise to a new individual without the sexual process.

Symbiosis: The obligatory association of two organisms of different species for mutual benefit.

Synapsis: Union in pairs of corresponding (homologous) chromosomes of opposite parental origin as a preliminary to their separation in meiosis.

Systematist: An expert in classification (systematics), *i.e.*, a taxonomist.

Taxonomy: The science of classification.

Tertiary Period: A geological time-division corresponding to the rock-system that comprises the greater part of the Cenozoic group. It is made up of four series, namely, the Eocene, Oligocene, Miocene, and Pliocene. Its close marks the beginning of the Glacial or Pleistocene epoch.

Tissue: A layer of uniform cells specialized for the same function.

Tissue Cell: One of the somatic cells of which a tissue is composed.

Troglodytic: Resembling the chimpanzee and the gorilla.

Woods Hole: The seat of the Marine Biological Laboratory. It is a watering-place on the New England coast opposite Martha's Vineyard.

Zygote: The synthetic cell formed by the union of two gametes and giving rise by division either to a new multicellular organism, or to a rejuvenated cycle of unicellular forms.

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